INTERMITTENT MANDATORY VENTILATION DURING GENERAL ANAESTHESIA FOR GERIATRIC PATIENTS UNDERGOING HIP FRACTURE SURGERY

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SYNOPSIS

Intermittent mandatory ventilation (IMV) was employed as the mode of ventilation during general anaesthesia in forty geriatric patients undergoing surgery for hip fractures. Anaesthesia was maintained at a light plane by noting muscle tone, spontaneous ventilatary effort, blood pressure and pulse. No deterioration of the electrocardiogram was noted during operation. Intraoperative blood-gas analysis showed absence of carbon dioxide retention and improved oxygenation. No patient had respiratory difficulty in the immediate postoperative period.

INTRODUCTION

Elderly patients with hip fractures always present an anaesthetic problem. For those suffering from pulmonary disease with hypercapnia and hypoxaemia, spinal or epidural analgesia probably is the best solution. Spinal or epidural analgesia however necessitates placing patients in the lateral position, and the process of positioning itself results in much pain. For those patients without gross pulmonary disease or those with bed-sores, or in patients who are not cooperative, general anaesthesia certainly has a place.

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Prolonged general anaesthesia using volatile anaesthetics.while allowing spontaneous ventilation leads to carbon dioxide retention and increased alveolar/arterial PO_2 difference (1). The latter is as a result of increased shunting because of an increase in the volume of trapped air.

Light general anaesthesia employing controlled mechanical ventilation (CMV), facilitated by the use of neuromuscular blocking drugs, often results in hyperventilation and respiratory alkalosis, causing a fall in cardiac output, a fall in cerebral blood flow, a shift of the oxygen dissociation curve to the left, and a rise in oxygen consumption (2, 3). Furthermore reversal at the termination of surgery may present difficulty in the elderly, fragile, and sometimes obese patients, resulting in postoperative ventilatory insufficiency.

CMV can be employed without the use of neuromuscular blocking drugs during deep general anaesthesia. This, however, often causes excessive cardiovascular depression in the eldery patient. Hypocapnia again is a possibility.

Intermittent mandatory ventilation (IMV) avoids the disadvantages of the above techniques and may be valuable if employed during anaesthesia for surgery not requiring muscle relaxation (4). The present study was carried out to confirm this in a group of geriatric patients undergoing hip fracture surgery.

MATERIALS AND METHODS

Equipment

Modification of the Manley MPT (5) and Brompton Manley Ventilator (6), to include an inspiratory reservoir which is separated from the ventilator circuit by a unidirectional valve, have been described to allow IMV, but the Manley Servovent Model MS (Medishield, United Kingdom) can be used without modification for the same purpose (4).

The Manley Servovent was connected to the closed anaesthesia circuit where the reservoir bag would normally be placed (Figure 1). During a mechanical inspiration, valve V_1 closes and whatever mandatory volume that is delivered from the bellows goes to the patient's lungs. During the expiratory phase of the ventilator, valve V_1 opens and allows fresh gas and the patient's expired gas (having passed through the soda lime absorber) to pass on to the reservoir bag and thence spilled to atmosphere via valve V_2. In the meantime the bellows also fills from the reservoir bag. Should the patient take in a spontaneous breath during the expiratory phase of the ventilator, he can do so by breathing in the anaesthetic gas mixture from the reservoir bag via valve V_1 which is open at this time.

Patients and Methods

Forty patients with hip fractures for elective surgery were included in the study. Eleven were male and twenty-nine, female. Age ranged from 62 to 100 yr (mean 79.5 yr). Body weight was unobtainable because of the hip fracture. Most Chinese patients of the above age range weigh between 45 and 55 kg. Preoperative laboratory investigation included haemoglobin estimation, renal and liver function tests, and arterial blood-gas analysis. Complicating pathology and types of operation performed are listed in Tables 1 and 2.

Premedication depended on the general condition of the patient. None was given for the very weak, while pethidine 40 mg and atropine 0.4 mg were prescribed for the stronger patient. An intravenous drip was set up prior to anaesthesia. Electrocardiogram was monitored and blood pressure was measured with a sphygmomanometer.

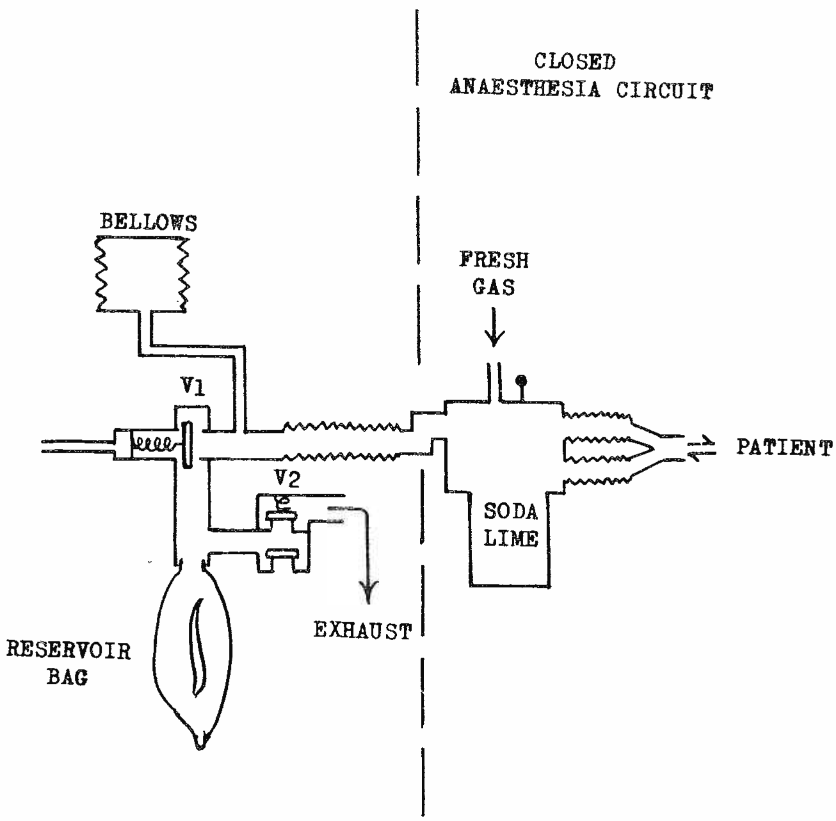

FIGURE 1. IMV circuit in the Manley Servovent attached to the closed anaesthesia circuit where the reservoir bag would normally be placed. During the expiratory phase of the ventilator, valve V_1 opens and allows fresh gas and the patient's expired gas (having passed through the soda lime absorber) to pass on to the reservoir bag and thence spilled to atmosphere via valve V_2. Should the patient take in a spontaneous breath during the expiratory phase of the ventilator, he can do so by breathing in from the reservoir bag via valve V_1 which is open at this time.

TABLE 1
COMPLICATING PATHOLOGY IN THE PATIENTS WITH HIP FRACTURES

Complicating pathology	No. of patients*
Hypertension	10
Ischaemic heart disease	7
Bedsore	7
Diabetes mellitus	6
Anaemia	5
Previous cerebrovascular accident, with hemiparesis	5
Uraemia	4
Dementia	2
Kyphoscoliosis	2
Chronic obstructive airway disease	1
Parkinsonism	1

*Some patients had more than one complicating disease.

TABLE 2
TYPES OF OPERATIONS

Operation	No. of patients
A.M. prosthesis insertion	21
Hip compression	19

General anaesthesia was induced with a sleeping dose of intravenous thiopentone or Althesin, allowance being made for a slow circulation. This was followed by intravenous suxamethonium. The larynx was sprayed with 60 mg of 10% lignocaine (Astra, Sweden) before orotracheal intubation. The lungs were then ventilated with the Manley Servovent connected to a circle system with a Boyle Mark IV absorber in circuit. Tidal volume was set at 400 ml, and frequency at 10 per min, with an inspiratory: expiratory ratio of 1:3. 33% oxygen was given in nitrous oxide. After flushing the circuit with an initial high flow, the total flow rate of oxygen and nitrous oxide from the anaesthetic machine was adjusted to 3 litres min^{-1}.

Enflurane or halothane was added to the oxygen/nitrous oxide mixture from a vaporizer outside the circle. During the early stage of maintenance of anaesthesia, patients with impaired pulmonary function needed longer period of higher inspired concentration of the volatile anaesthetic before stabilization took place because of impaired uptake. Frequent measurement of blood pressure was mandatory initially because of the possibility of pre-existing dehydration due to poor preoperative fluid intake.

Spontaneous breathing returned quickly. Fentanyl 25μg was given intravenously before skin incision. The lowest concentration of enflurane/halothane required to maintain anaesthesia was then established by noting muscle tone, spontaneous ventilatory effort, blood pressure and pulse. Thirty minutes after resumption of spontaneous respiration an arterial blood sample was taken for blood-gas analysis; at the same time, expired minute ventilation was measured with a Wright's respirometer. The minute volume measured included both mandatory and spontaneous breaths.

Blood loss was fully replaced by blood transfusion during the operation. Anaesthesia and ventilatory support were withdrawn as soon as the skin wound was closed. The patient was then extubated.

Arterial blood-gas analysis was again performed in the recovery room 30 minutes after termination of anaesthesia, all patients having been breathing room air for at least 15 minutes before blood sampling.

RESULTS

Duration of anaesthesia ranged from 45 to 180 min (mean 88 min).

Blood pressure remained stable throughout operation except initially in the few with pre-existing dehydration. No deterioration in the electrocardiogram was observed.

All patients maintained spontaneous breathing during IMV while undergoing surgery. Intraoperative blood-gas analysis showed absence of carbon dioxide retention; PaO_2 values invariably showed significant improvement over preoperative figures (Table 3). Simultaneously measured expired minute volume (mandatory and spontaneous ventilation) ranged from 4.3 to 8.8 litres (mean 6.0 liters).

Normal spontaneous breathing returned quickly after anaesthesia and ventilatory support were withdrawn at the conclusion of surgery. All patients regained consciousness on arrival in the recovery room. No respiratory difficulty was encountered clinically in any of the patients. Thirty minutes after termination of anaesthesia, while the patients were breathing room air, both $PaCO_2$ and PaO_2 did not differ significantly from the preoperative values (Table 3).

Blood-gas results obtained intraoperatively and post-operatively were compared statistically with those before opeation by Student's t test.

TABLE 3
ARTERIAL BLOOD-GAS DATA (MEAN ± SD) BEFORE, DURING AND AFTER OPERATION

	Before operation (F_IO_2 = 0.21)	During operation (spontaneous breathing + IMV) (F_IO_2 = 0.33)	After operation (F_IO_2 = 0.21)
pHa	7.464 ± 0.033	7.439 ± 0.037***	7.433 ± 0.039****
$PaCO_2$ (kPa)	4.84 ± 0.62	5.03 ± 0.63**	4.80 ± 0.70*
PaO_2 (kPa)	10.27 ± 1.36	17.89 ± 3.51****	10.19 ± 1.63*
Base excess (mmol.1^{-1})	3.36 ± 3.29	2.22 ± 2.87**	0.88 ± 2.93****

Intraoperative and postoperative results were compared statistically with those before operation by Student's t test.

* $P>0.7$
** $P>0.1$
*** $P<0.01$
**** $P<0.001$

DISCUSSION

Enflurane and halothane produce essentially the same cardio-vascular changes. Except in uraemic patients, halothane probably is second choice to enflurane in geriatric patients because of an increase in drug metabolites due to increased body fat and possible hypoxaemia. In addition, the Enfluratec (Cyprane, United Kingdom) allows fine concentration adjustments from 0 to 1%; this is a bonus because some of our patients required only 0.4 to 0.6% enflurane for maintenance of anaesthesia. With the Fluotec Mk III (Cyprane, United Kingdom), however, the lowest permissible concentration setting is 0.5% and this may be excessive for some of the geriatric patients.

IMV is a method of mechanical ventilation employed in the intensive therapy unit, mostly for weaning patients from mechanical ventilation (7, 8). Advantages claimed include safe easy weaning, decreased duration of ventilation and decreased respiratory alkalosis (6).

In the present series of patients, IMV was employed as the mode of ventilation under anaesthesia. Anaesthesia was kept at a light plane to allow spontaneous ventilation to resume. Spontaneous ventilatory effort, muscle tone, blood pressure and pulse were useful as guides to make sure that the plane of anaesthesia was light. It is known that surgical stimulus will restore a PCO_2/ventilation response curve displaced by a general anaesthetic (9). In other words, under light general anaesthesia surgical stimulus tends to restore the displaced apnoeic threshold PCO_2 towards that of the conscious state. Thus all patients in the study maintained spontaneous breathing during IMV. The ability of the patients to maintain normocapnia while under light anaesthesias employing IMV was demonstrated by the result of the present study.

The main disadvantage peculiar to IMV under anaesthesia is the transient high intrathoracic pressures which may be generated when a spontaneously breathing patient expires against a mandatory mechanical inflation. However, this would in effect provide a "sigh" which some consider as advantageous (6). Furthermore excessively high pressure build-up is prevented by the safety blow-off valve incorporated in the circuitry of the Manley Servovent.

The technique of anaesthesia described can conceivably be used for other types of surgery not requiring muscle relaxation. It is especially advantageous in the weak and debilitated or obese patient.

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