CONTROLLED ANAESTHESIA:
A CLINICAL EVALUATION OF AN APPROACH USING PATIENT CHARACTERISTICS IDENTIFIED DURING UPTAKE

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SUMMARY

The performance of a system to control the alveolar concentration of halothane in patients undergoing halothane and nitrous oxide or halothane anaesthesia with controlled ventilation has been evaluated. The method involved the identification and quantification of the uptake characteristics of patients from their early response to the anaesthetic and implements the vaporizer control necessary to achieve and maintain a desired alveolar halothane concentration. Initial targets are based on the concept of MAC, but modifications to the desired alveolar concentration may be effected readily by the anaesthetist at any time during the procedure if evaluation of the normal clinical signs indicates inappropriate depth of anaesthesia. The results obtained during anaesthesia for routine surgery in 80 patients demonstrated that the system was accurate, stable, robust and able to adapt for variability between patients in the uptake of halothane.

The automatic control of anaesthesia has interested investigators for many years. Several reports of systems designed to control the depth of anaesthesia have appeared in the literature and these have been reviewed recently by Chilcoat (1980). However, there is at present no well-defined, unequivocal, measurement of the depth of anaesthesia and, consequently, such systems have been designed to control the depth of anaesthesia indirectly from observation of some parameter, or group of parameters, which is assumed to relate closely to "depth". When inhalation agents are considered the concept of MAC (minimum alveolar concentration) (Saidman and Eger, 1964) can be used to quantify the depth of anaesthesia in a more precise and universal manner than can be achieved from an evaluation of clinical signs (Eger, 1978). The effects of premedicant and other drugs or agents used in the anaesthetic sequence can be expressed in terms of fractions of MAC. Other factors influencing MAC, for example age, can also be taken into consideration and the required alveolar anaesthetic concentration determined. Whilst 1 x MAC produces anaesthesia in 50% of the population, it has been reported that 1.3 x MAC provides adequate anaesthesia in 95% of patients (de Jong and Eger, 1975). Thus, this index provides the anaesthetist with a quantified control objective in terms of alveolar anaesthetic concentration to be achieved and maintained by the automatic system.

A method for the automatic control of anaesthesia using inhalation agents, namely control of the anaesthetic concentrations in alveolar gas, has been described recently. This system was investigated in simulation studies and analysed off-line using data from patients undergoing clinical anaesthesia with halothane. The results indicated the feasibility of the technique as a method for the control of anaesthesia (Tatnall, Morris and West, 1981). This report describes the implementation of this system and its use in automatically controlling the administration of halothane to patients of varying ages undergoing routine clinical anaesthesia with intermittent positive pressure ventilation (IPPV). Results and analysis of the performance of the system are presented, and its behaviour in responding to changes in the desired alveolar halothane concentration illustrated.

METHODS AND ASSESSMENT

Methods

The objective of the system is to provide control of the depth of anaesthesia via precise and stable control of the alveolar concentration of the anaesthetic agent. Since the factors influencing anaesthetic uptake cannot be determined from readily available patient data the system was designed to perform an analysis of individual uptake characteristics based upon the patients' initial alveolar response to the agent. The system is thus self-adaptive, requires no
preprogramming, and takes account of the large variability occurring in the response of individual patients. To achieve this objective the control procedure comprises three stages. The first, parameter identification, occurs during the first nine respiratory cycles following the introduction of the agent when the inspired concentration \( (F_l) \) is set to its maximum permitted value \( (F_{l\text{max}}) \) and an overpressure procedure is commenced. No control of \( F_l \) is effected during this period whilst a computer identification routine analyses the patient alveolar response to the inspired concentration and quantifies the principal parameters \( (K_1 \) and \( K_2 \)) involved in this relationship. Immediately following these calculations and starting at the 10th respiratory cycle this information is applied to the required control to \( F_l \) (stage two) in order to achieve and maintain the desired alveolar concentration \( (P_{A_d}) \). If, however, at the 10th breath the alveolar concentration \( (PA) \) has not yet reached \( P_{A_d} \) then \( F_{l\text{max}} \) is maintained until \( P_{A_d} \) is achieved. The derivation of a suitable control law for \( F_l \) during early uptake and the identification of \( K_1 \) and \( K_2 \), which are assumed to remain substantially constant during this period, has been discussed (Tatnall, Morris and West, 1981). When implemented on a breath-by-breath basis, this control law takes the form of equation (1):

\[
F_l(n) = \frac{(K_1 + K_2)}{K_2} P_{A_d} - \frac{K_1}{K_2} P_V(n - m) \tag{1}
\]

where \( F_l(n) \) is the inspired concentration at the \( n \)th breath and \( m \) quantifies, in terms of number of respiratory cycles, the time lags resulting from measurement, computation, and transport of halothane from the vaporizer to the patient. The parameters \( K_1 \) and \( K_2 \) relate to lung perfusion and ventilation which vary significantly from patient to patient. \( P_V(n - m) \) is an estimate of the partial pressure of the mixed venous blood entering the lungs at the \( (n - m) \)th breath. This latter state is tracked using measured values of \( PA \) and \( F_l \) and the identified values of \( K_1 \) and \( K_2 \). The value \( m \) is not measured by the system or required for implementation of the control law, but is implicit in this law which states that at the \( n \)th breath the value of \( P_V \) used to determine the inspired concentration \( (F_l(n)) \) is the latest available value, that is \( P_V(n - m) \). In practice, \( m \) is equivalent to two to four respiratory cycles. An analysis of the system response (Montgomery, 1983) demonstrated that its stability was not influenced by values of \( m \) encountered in normal anaesthetic delivery systems.

It may be seen from equation (1) that the control of \( PA \) during stage two depends on the ability of the vaporizer to deliver precisely the concentration defined in this control law. In practice this degree of vaporizer output control may not be achieved and therefore, to eliminate the small steady-state errors between \( PA \) and \( P_{A_d} \), resulting from any small error in vaporizer output and as a result of variation in the constitution of the carrier gas, a low gain integral term was added to the control law defined by equation (1). To prevent perturbation of \( F_l \) resulting from scatter, measurement noise or isolated measurement error, a digital, weighted, least squares smoothing technique based on a second order polynomial fit was applied, breath by breath, to the values obtained for \( P_V \).

The third stage of the control procedure starts after 90 respiratory cycles, when the rate of change of \( F_l \) has decreased. During this period maintenance of \( PA \) at \( P_{A_d} \) is achieved using a standard proportional plus integral (PI) type of control law. This simplified mode of control, designed to eliminate any errors between the desired and actual alveolar concentrations, is now appropriate for regulation of \( PA \) during the maintenance period of anaesthesia. The control law used at this stage is described by equation (2):

\[
F_l(n) = K_3 e(n - m) + K_4 \Sigma e(n - m) \tag{2}
\]

where \( e = P_{A_d} - PA \). The proportional and integral gains, \( K_3 \) and \( K_4 \), respectively, are assigned from a knowledge of the controlled process, \( \Sigma \), the patient response characteristics, as quantified by the identified parameters \( K_1 \) and \( K_2 \). \( K_3 \) and \( K_4 \) are automatically scheduled by the computer control to ensure that the final closed-loop system is both stable and has a rapid response. The last available measurements of \( e \) and \( F_l \) are used to evaluate the initial value for the integrated error term \( \Sigma e \) at the commencement of this third stage of the procedure.

The computation necessary to perform the patient parameter identification and determine the required vaporizer control was carried out on an Apple II, 48K, general purpose microcomputer. Communication between the computer and the incoming analog quantities is carried out by 8-bit analog to digital converter (ADC) units. Outgoing information and the control of a servo-vaporizer is achieved using digital-to-analog converters (DAC). Figures 1 and 2 show the apparatus in diagrammatic
Fig. 1. Schematic diagram showing automatic alveolar concentration control system.

Fig. 2. The automatic control system in use in the operating theatre.
form and in use in the operating theatre, respectively.

The concentrations of halothane required to implement the control system were measured using a rapid-response u.v. halothane meter (Tatnall, West and Morris, 1978) situated in the expiratory limb of the ventilator circuit as described previously (Morris, Tatnall and West, 1979). The control unit for this transducer determines current values of Fl and PA from the continuous measurement of the expired halothane concentration. Fl was quantified by measurement of the concentration in the initial fraction of the expired gas (the deadspace gas), the end-tidal concentration being assumed to represent PA. A maximum- and minimum-hold facility was used to obtain these values which were reset at each respiratory cycle. These values are supplied to the microcomputer and also displayed in both analog and digital form. The onset of each new respiratory cycle is signalled by the displacement of small bellows situated in the expiratory limb of the anaesthetic delivery system downstream of the halothane meter. The signal obtained by this method resets the values of Fl and PA at each breath and indicates to the computer the provision of new data. Halothane was administered from a Fluotec Mk III vaporizer with a concentration control mechanism driven by a geared d.c. servo-motor. A multi-turn linear potentiometer was used in the device to supply a feedback voltage proportional to the angular position of the control spindle. Fl was controlled by the computer via a DAC using a calibration relating feedback voltage to the vaporizer output and allowing 256 positions of the vaporizer spindle corresponding to halothane concentrations between 0 and 2.5%. The computer keyboard provided the means of entering patient information which is requested by the program in an interactive fashion from a small visual display unit (VDU) and no special expertise is required to operate the system. The VDU was also used as a high resolution graphics display to show the breath-by-breath response of the patient during the control procedure (fig. 2). All patient details, including a complete record of the anaesthetic uptake in the form of the Fl and PA values for the first 90 respiratory cycles, were stored using a 5-in floppy disc system. A Silentype thermal printer was used to plot and tabulate the anaesthetic concentrations stored on the disc and to print patient data. The anaesthetic concentrations obtained directly from the halothane meter were also recorded throughout the procedure, independently of the computer system, using a

Record 100 MSR chart recorder.

High frequency filters, digital smoothing and a diathermy detection circuit were used to make the system resistant to measurement noise. A clear indication is provided in the event of the occurrence of any of the following:

(i) $F_l_{\text{max}}$ or $P_A_d$ as defined by the anaesthetist, outside of accepted values, viz $0.5% < F_l_{\text{max}} < 3.0%; 0.2% < P_A < 1.4%$.

(ii) Mismatch between vaporizer setting and the inspired concentration measured at the patient, that is, if $(F_l_{\text{required}} - F_l_{\text{measured}})/F_l_{\text{measured}} > 0.2$. This indicator provides a warning in the event of vaporizer or halothane meter malfunction.

(iii) $F_l_{\text{measured}}$ greater than $F_l_{\text{max}}$.

(iv) Failure to control $P_A$ to $P_A_d$.

In addition the voltages of the DAC outputs, the servo-vaporizer feedback and the servomotor supply can be monitored at the vaporizer control unit. If values of the identified parameters are outside the range normally encountered in man or if measurement noise corrupts the data used to determine these parameters, then the normal mode of control is abandoned. In this event Fl is set to $P_A_d$, a warning given, and the anaesthetist requested to take manual control. In the schema of the system, depicted in figure 1, the broken lines indicate states observed by the anaesthetist during the control procedure.

For the purpose of this study it has been assumed that a total anaesthetic dose equivalent to a value of $1.3 \times \text{MAC}$ provides optimal depth of anaesthesia for surgery. In the determination of $P_A_d$ (halothane) for individual patients account must be taken of the additive effect, in respect of MAC units, of all other agents used in the procedure. For example, during induction premedicant drugs will provide an MAC equivalent of between 0.1 and 0.2 MAC units and in addition the dose of thiopentone at induction will temporarily contribute a similar MAC equivalent (Van Poznak, 1979). Subtracting the MAC equivalent of these drugs and the contribution made by nitrous oxide, when applicable, from a total of $1.3 \times \text{MAC}$, provides $P_A_d$ (halothane) in units of MAC which are then convertible to concentrations, for example $1 \times \text{MAC}$ (adult) = 0.74% halothane. Assuming that MAC for all the agents administered
varies with age in a manner described for halothane by Gregory, Eger and Munson (1969), a similar calculation may be used to determine the alveolar halothane concentrations appropriate for the paediatric patient.

**Assessment**

The control system was used during anaesthesia for routine abdominal, urological, plastic or orthopaedic surgery in 80 patients, ASA Class I–III, aged 7 months to 62 yr, the study being approved by the Ethics Committee of the Salford Health Authority. $P_{A_d}$ (halothane) was determined for each patient as described above. Premedication was given by mouth 2.5 h before operation. For patients weighing less than 25 kg, this comprised trimeprazine tartrate 3 mg kg$^{-1}$, for patients weighing 25–35 kg it was lorazepam 1.25 mg and droperidol 2.5 mg and for patients weighing more than 35 kg lorazepam 2.5 mg and droperidol 5.0 mg.

Before commencing the anaesthetic, the calculated $P_{A_d}$ and $F_{\text{max}}$ (generally of the order of $3 \times P_{A_d}$) were entered into the computer by means of the keyboard. In addition, patient details including age, weight, respiratory rate, minute volume and case number were entered for the purpose of record and reference. An i.v. infusion was established and anaesthesia induced with thiopentone 4–6 mg kg$^{-1}$ to a maximum dose of 300 mg. Pancuronium 0.1 mg kg$^{-1}$ was administered and the trachea intubated with a snug fitting Portex uncuffed oral tracheal tube in patients aged less than 10 yr or a cuffed red rubber oral tracheal tube in older patients. IPPV was commenced with either 70% nitrous oxide in oxygen or 100% oxygen using a Blease Pulmoflator with the paediatric attachment or a Manley (MN2) Ventilator, as appropriate. The delivered minute volume was calculated to maintain $P_{\text{aco}}$ 4.6–5.3 kPa (Nunn, 1977).

Halothane was administered from the servo-vaporizer by the automatic control system activated via the computer keyboard. When nitrous oxide was used in the inspired gas the administration of halothane was delayed for 2–3 min to allow virtual patient equilibrium with nitrous oxide (Epstein et al., 1964). This short delay prevented the enhanced uptake of halothane occurring during the simultaneous administration of high concentrations of nitrous oxide (second gas effect) from influencing the quantification of the identified patient parameters, $K_1$ and $K_2$. Heart rate, ECG and temperature were monitored continuously. Systolic arterial pressure was recorded frequently either by manual indirect sphygmomanometry or using a Dinamap Vital-Signs Monitor. The alveolar halothane concentration can be increased or decreased during induction or maintenance if clinical signs indicate either inadequate “depth” or adverse patient responses such as unwanted hypotension. This is carried out by pressing any key on the computer keyboard and responding to the computer’s immediate request for changes in the desired alveolar concentration. The system then responds rapidly to achieve and maintain the new level.

Towards the end of surgery the halothane was discontinued by requesting, as described above, an alveolar concentration of zero. The decrease in the alveolar concentration could be observed on the VDU and the continuous chart recording. On completion of surgery residual neuromuscular blockade was antagonized with neostigmine 0.07 mg kg$^{-1}$ and atropine 0.02 mg kg$^{-1}$ i.v. Ventilation was continued with 100% oxygen and the tracheal tube removed when spontaneous respiration had been re-established.

**RESULTS**

The automatic system provided stable and accurate control of the alveolar halothane concentration during the initial over-pressure procedure and throughout maintenance. The system was able to adapt for all patient physiological variability and in no instance was control abandoned because of unacceptable transient or inaccurate steady-state behaviour resulting from the failure of the system.

The following results have been selected principally to illustrate the following features:

(i) The capacity to accommodate for the large variability in individual patient response.

(ii) Resistance to measurement disturbances as a result of diathermy etc.

(iii) The ability to implement, when required, changes in the desired patient alveolar partial pressure.

A typical result showing a record of the first 90 respiratory cycles following the introduction of halothane is shown in figure 3. This figure is an annotated copy of a computer print-out obtained from data retrieved from the disc storage system as reproduced on the Silentype printer. In this exam-
Fig. 3. An annotated computer printout showing an automatically controlled procedure and numerical values of $F_1$ and $P_A$ for the first 12 respiratory cycles. Patient: 24 yr, 70 kg; operation: SMR; minute volume $= 6.5$ litre min$^{-1}$; nitrous oxide and halothane; $F_{1\text{max}} = 1.2\%$; $P_{Ad} = 0.5\%$. (Also included on the full printout are patient's name, case number, date and respiratory rate.)

The best least squares fit obtained from $P_A$ for the first eight breaths, as used in the computation of $K_1$ and $K_2$, is shown by the unbroken curve. A large scatter or deviation of $P_A$ (measured) from this line is indicative of less reliable parameter identification and is quantified by the least squares residual associated with the determination of $K_1$ and $K_2$. In one case the residual indicated an unsatisfactory identification resulting from electrical noise corrupting the $P_A$ measurements during the first eight breaths. In this case an alarm was given, the over-pressure procedure halted, $F_1$ reduced automatically to $P_{Ad}$ and control returned to the anaesthetist.

The lowest curve, commencing at the 14th breath, is the smoothed estimate of the tracked value of $P_{\bar{v}}$. The individual, unsmoothed $P_{\bar{v}}$ values which are calculated starting from breath 9 are also shown.

Figure 4 shows an example of the $F_1$ and $P_A$ values measured by the halothane meter and recorded by the pen recorder breath by breath, during the entire procedure. The excessive excursions shown in this plot are the result of the effect of diathermy on the monitoring system. This chart recording indicates the long-term accuracy achieved by the system and the decrease in $P_A$ following withdrawal of halothane.
Figure 5 is representative of results obtained when nitrous oxide is not included in the anaesthetic sequence. It is seen that $F_i_{\text{measured}}$ exceeded $F_i_{\text{max \ defined}}$ and $P_A_{\text{measured}}$ initially overshot $P_{A_d}$. Each of these discrepancies is associated with the increased output from the Mk III Fluotec vaporizer when oxygen alone was used as the carrier gas. The control system recovered fully from this calibration anomaly and precise control to $P_{A_d}$ was achieved following a small initial overshoot. Figure 6 is the continuous chart recording of the same procedure showing a response to surgery and the subsequent automatic controlling action of $F_i$ to restore $P_A$ to $P_{A_d}$. The absence of any system response to disturbances resulting from diathermy is again shown clearly.

In three patients, because of a decrease in $P_A$ associated with surgical stimulation, it was necessary to increase $P_{A_d}$ from the value originally determined. In one patient $P_{A_d}$ was decreased because of unacceptable cardiovascular depression.

Figures 7 and 8 illustrate the response of the system to keyboard commands to increase and decrease $P_{A_d}$ by computer control. In both figures $P_{A_{\text{ori}}}$ and $P_{A_{\text{mod}}}$ respectively represent the original and modified estimates of the appropriate alveolar halothane partial pressure as ordered by the anaesthetist. These changes were initiated during maintenance when the system is under PI control.

As described previously, considerable variations exist between patient response characteristics. Fig-

**Fig. 5.** A computer printout of a controlled procedure showing increased vaporizer output when oxygen only is used as the carrier gas. Patient: 8 yr, 18.5 kg; operation: right orchidopexy; minute volume = 3.4 litre min$^{-1}$; RR: 16 b.p.m.; $F_i_{\text{max}}$ = 2%; $P_{A_d}$ = 0.9%.

**Fig. 6.** A chart recording of an automatically controlled procedure (first 90 respiratory cycles shown in figure 5), showing response to surgery and subsequent control.
FIG. 7. Chart recording showing response to keyboard instruction to increase $P_{A_d}$ during maintenance. Patient: 5 yr, 22 kg; operation: bilateral reimplantation of ureters; minute volume = 3.7 litre min$^{-1}$; nitrous oxide and halothane; $P_{A_{II}} = 0.5$%; $P_{A_{III}} = 0.75$%.

FIG. 8. Chart recording showing response to keyboard instruction to decrease $P_{A_d}$ during maintenance. Patient: 11 yr, 21 kg; operation: creation of arteriovenous fistula; minute volume = 3.5 litre min$^{-1}$; nitrous oxide and halothane; $P_{A_{II}} = 0.7$%; $P_{A_{III}} = 0.5$%.
Fig. 9. Computer printout from a typical slow response patient showing \( F_l \) maintained at \( F_{\text{max}} \) until \( P_A \) reached \( 0.95 \times P_{Ad} \). Patient: 4 yr, 21.4 kg; operation: bilateral reimplantation of ureters; minute volume = 3.75 litre min\(^{-1}\); RR: 16 b.p.m.; nitrous oxide and halothane; \( F_{\text{max}} = 1.75\%; P_{Ad} = 0.7\% \).

Fig. 10. Computer printout from a fast response patient showing \( F_l \) maintained at \( F_{\text{max}} \) until completion of the parameter identification procedure leading to a transient overshoot of \( P_A \) above \( P_{Ad} \). Patient: 62 yr, 60 kg; operation: SMR; minute volume = 6 litre min\(^{-1}\); RR: 12 b.p.m.; nitrous oxide and halothane; \( F_{\text{max}} = 0.8\%; P_{Ad} = 0.3\% \).

Fig. 11. Computer printout showing the control obtained in the youngest patient. Patient: 7 months, 6.5 kg; operation: right inguinal herniotomy and orchidopexy; minute volume = 1.1 litre min\(^{-1}\); RR: 20 b.p.m.; nitrous oxide and halothane; \( F_{\text{max}} = 1.5\%; P_{Ad} = 0.6\% \).
ble time given the constraint of $F_{1\text{max}}$ used in the over-pressure administration.

The results obtained in this clinical evaluation of the system confirm the previous theoretical simulation and off-line studies regarding the capacity of the system to adapt for all patient variability. They further showed that the electronic and digital filtering is successful in eliminating the problems normally associated with measurement noise, including diathermy, and that stable and reliable control was achieved in the clinical environment. The system imposed no constraints on the surgical procedure and is unobtrusive in use in the operating theatre, the microcomputer and control apparatus being accommodated on a small theatre trolley (fig. 2).

The control system was designed around readily available anaesthetic apparatus, is simple to use and the anaesthetist is able at all times to alter $F_{1\text{max}}, P_{A_d}$ or return to manual vaporizer control. To ensure that the patient received the $F_{1}$ value called for by the computer from the servo-vaporizer an anaesthetic delivery system having a rapid response to changes in $F_{1}$ should be used in order to achieve and maintain $P_{A}$ at $P_{A_d}$ during the early part of the automatically controlled over-pressure procedure. Ventilators of the minute volume dividing type have been found to satisfy this requirement. The increased vaporizer output occurring when oxygen only is used as the carrier gas has been described (Lin, 1980). This phenomenon results in overshoot of both $F_{1\text{max}}$ and $P_{A}$ from their target values when the vaporizer calibration quantified in the computer program on the basis of a nitrous oxide plus oxygen mixture is used for oxygen and halothane administration as is shown in figure 5. Until the integral control action (introduced to eliminate small steady-state errors) becomes effective the administered $F_{1}$ (assumed correct by the computer calibration) is in fact marginally greater than that required and consequently $P_{A}$ achieves a proportionally greater value, overshooting $P_{A_d}$. Other causes of small initial overshoots of $P_{A}$ beyond $P_{A_d}$ are over-ventilation, which results in an enhanced rate of increase in $P_{A}$, and the application of a high $F_{1\text{max}}$ to a rapid response type of patient. In all instances the system corrects for this transient $P_{A}/P_{A_d}$ discrepancy.

A feature of the measurement of alveolar concentration is that it reveals increases in cardiac output resulting from cardiovascular responses to surgery (fig. 6) as previously described by the authors (Morris, Tatnall and West, 1979). This may be interpreted as a sign of inadequate anaesthesia calling for an increase in $P_{A_d}$.

Control of $P_{A}$ (halothane) to the value $P_{A_d}$ which may be calculated using the concept of MAC has been shown to be a practical, safe and non-invasive approach to the control of depth of anaesthesia. The same technique may be applied to any volatile agent, for example enflurane, where measurement of $F_{1}$ and $P_{A}$ (agent) is available.

The philosophy and method of controlling $P_{A}$ can be extended to the control of other variables which may be considered to relate more closely to anaesthetic depth. For example, given a quantified relationship between evoked brain potentials and depth of anaesthesia the identification and control associated with this variable, rather than with $P_{A}$, would provide the basis for control.

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CONTROLLED ANAESTHESIA: CLINICAL EVALUATION

ANESTHESIE CONTROLEE: ETUDE CLINIQUE D'UNE METHODE UTILISANT LES CARACTERISTIQUES INDIVIDUELLES DEFINIES PENDANT LA CAPTATION

RESUME
Nous avons etudie les performances d'un systeme de controle de la concentration alveolaire d'halothane chez des patients subissant une anesthesie a l'halothane seul ou associe au protoxyde d'azote en ventilation controlee. La methode comportait l'identification et la quantification des caracteristiques de la captation chez chaque patient a partir de sa reponse precoce a l'administration d'anesthesique et mettait en jeu le controle du vaporisateur necessaire pour obtenir et conserver une concentration alveolaire d'halothane fixee. Au depart, le but recherché était de definir l'objectif a partir de la notion de MAC mais l'anesthesiste pouvait facilement modifier les donnees pour obtenir la concentration alveolaire qu'il souhaitait a n'importe quel moment si l'observation des signes cliniques habituels indiquait une profondeur inadequate d'anesthesie. Les resultats observes au cours de l'anesthesie pour chirurgie usuelle chez 80 patients ont montré que le systeme etait precis, stable, robuste et capable de s'adapter aux differences individuelles de captation de l'halothane.

ANESTESIA CONTROLADA: UNA EVALUACION CLINICA DE UN ENFOQUE EN QUE SE USA LAS CARACTERISTICAS DEL PACIENTE IDENTIFICADAS DURANTE LA CAPTACION

SUMARIO
Se llevó a cabo la evaluación del rendimiento de un sistema de control de la concentración alveolar de halotano en pacientes sometidos a una anestesia por halotano y óxido nitroso o con halotano, bajo ventilación controlada. El método comportaba la identificación y la cuantificación de las características de captación del paciente a raíz de su pronta respuesta al anestésico y empleaba el control del vaporizador necesario para lograr y mantener una concentración alveolar de halotano requerida. Los objetivos iniciales se basan en el concepto del MAC, pero las modificaciones deseadas de la concentración alveolar pueden ser practicadas fácilmente por el anestesiador en cualquier momento del proceso si la evaluación de las señales clínicas normales indica que el grado de anestesia es inadecuado. Los resultados logrados durante la anestesia para cirugía rutinaria en 80 pacientes indicaron que el sistema es exacto, estable, sólido y puede adaptarse según las variaciones de los pacientes en captar el halotano.