Abstracts

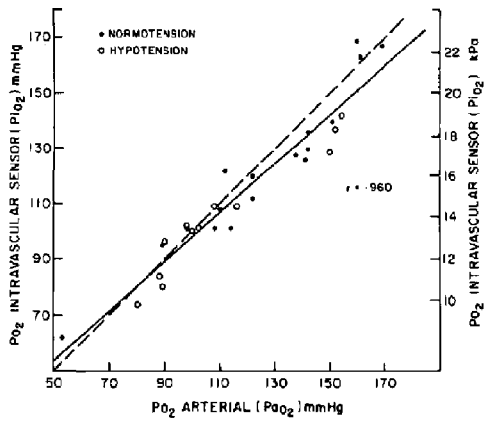
Continuous monitoring of oxygenation during hypotensive anaesthesia – evaluation of an intravascular PO_2 electrode

H.T. Kieraszewicz, A.M. Lam
Department of Anaesthesia, University Hospital, University of Western Ontario, London, Ontario.

The anaesthetic management of neurovascular surgical patients is guided by frequent measurements of arterial blood gases. However, the delay between the time of sampling and obtaining results is often unacceptable in rapidly changing haemodynamic situations. The development of intravascular oxygen electrodes provides a means of measuring the partial pressure of arterial oxygen (PaO_2) continuously. This study was undertaken to assess the performance of the intravascular oxygen (PiO_2) electrode during normotension and controlled hypotension in cerebral aneurysm surgical patients.

The intravascular PiO_2 sensor was aseptically introduced through an 18 G artery cannula in seven adult patients undergoing cerebral aneurysm clipping during isoflurane anaesthesia. Simultaneous observations of PaO_2 and PiO_2 were obtained at normotension (n = 17) and at hypotension, mean blood pressure ranging from 42–53 mmHg (n = 12). Linear regression analysis of these observations yielded for (I) normotension: $PiO_2 = 0.902\ PaO_2 + 9.30$ with a correlation coefficient (r) = 0.960 ($p < 0.001$); (II) hypotension: $PiO_2 = 0.79\ PaO_2 + 18.10$ with r = 0.961 ($P < 0.001$); and (III) overall: $PiO_2 = 0.881\ PaO_2 + 10.14$ with r = 0.96 ($p < 0.001$). The readings were independent of acid-base balance and PCO_2 within the same range studied.

The PO_2 recorded by the intravascular electrode correlated well with the simultaneous measurements of arterial O_2 tensions. The slight underestimation of arterial O_2 tensions during hypotension actually adds a margin of safety. The intravascular oxygen electrode appears to be reliable as a continuous monitor of oxygenation.



The performance of humidifiers equipped with heated gas delivery systems

D.J. Steward, G.A. Volgyesi
Department of Anaesthesia, The Hospital for Sick Children, Toronto, Ontario

Humidification of inspired gases is important to prevent respiratory tract damage and minimise heat loss. The ideal humidifier should be capable of delivering gases to the airway fully saturated at 37° C and should maintain constant levels of inspired gas water content and temperature despite minute to minute changes in gas flow rate. We have compared the performance of four humidifiers which are equipped with a heated gas delivery hose: the Fisher and Paykell (F & P) model #3286, which is provided with a manually controlled hose heater wire, the F & P model #3289, which has a servo controlled heater wire, the F & P model #MR 500, which has servo control of the heater wire and the water reservoir, and the Grant model I.M.24, which also has a dual servo control mechanism.

Methods

The temperature and water content of gases delivered to the endotracheal connector was measured as was the temperature of the water reservoir. Measurements were made during start-up from cold, and then at various flow rates and following interruptions to flow. Temperatures were measured using Yellow Springs thermistor probes. Water content was determined by passing the gases into a condenser, measuring the volume of condensate, and relating this to the gas flow rate.

Results

All the humidifiers tested were capable of delivering gases with a water content of 44 $mg \cdot L^{-1}$ at 37° C (full saturation) at constant flows from 2–20 $L \cdot min^{-1}$. Rain-out in the delivery tubes was negligible. The temperature and water content of delivered gas is very flow-rate

dependent in models without servo control. With variations in flow rate and particularly after interruptions to flow, some models were capable of delivering gases at transiently very high temperatures (see Table).

TABLE

Model	*Max. temp. (cont. flow)*	*Max. temp. (after interrupted flow)*
#3286	50	50
#3289	42	60
MR500	40	50
I.M.24	37	44

Conclusions

1 All the humidifiers evaluated are capable of delivering gases fully saturated at 37° C.
2 The humidifier (F & P #3286) with manual control of hose temperature may be set accidently to deliver gas at a constant temperature as high as 50° C.
3 The humidifier (F & P #3289) with servo control of delivered gas temperature only may deliver gases far in excess of the selected temperature for short periods following interrupted flow.
4 The humidifiers with dual servo control, reservoir and delivered gas temperatures (F & P #MR500, Grant I.M.24) showed less swing in temperature with changing flow rates and following interrupted flow.
5 The characteristics of any humidifier should be fully considered before incorporating it into a ventilator circuit. Inspired gas temperature should always be monitored.

Evaluation of transcutaneous PCO_2 measurement during anaesthesia

K.G. Smedstead, A.C.P. Powles
Department of Anaesthesia, McMaster University, Hamilton, Ontario

This study was designed to evaluate the use of a transcutaneous carbon dioxide electrode (Hewlett-Packard Capnometer) as an indicator of changes in arterial carbon dioxide tension ($PaCO_2$) in patients undergoing major surgery.

Non-invasive transcutaneous carbon dioxide ($PtCO_2$) sensors have been successfully used in neonates and in critical care unit patients.[1–3] One such instrument was shown to be a reliable indicator of PCO_2 trends in patients having neurosurgery under general anaesthesia.[4]

Patients undergoing vascular surgery and thoracotomy with one lung anaesthesia are subjected to marked changes in ventilation and perfusion intra-operatively. In order to evaluate whether a $PtCO_2$ electrode would accurately reflect wide and sudden fluctuations in $PaCO_2$, we selected 10 such patients for the study.

Methods

The instrument measures the partial pressure of CO_2 using a non-dispersive infrared technique. It consists of a heated skin piece positioned over a teflon membrane through which CO_2 diffuses. The skin piece chamber temperature is controlled at 39° C. The Sensor snaps on to the skin piece and detects the infrared wavelength absorption caused by the amount of CO_2 present in the chamber.

We first evaluated the instrument in eight normal volunteers in order to establish its accuracy and response time at different arterial pCO_2 tensions. The $PtCO_2$ electrode was attached to the subject's forearm according to manufacturer's instructions. End tidal PCO_2 was measured simultaneously by breathing through a mouthpiece from which CO_2 was sampled and analysed using a Goddard Capnometer and a four channel recorder. The subjects were taken through a sequence of normal ventilation, hyper- and hypoventilation, and rebreathing of CO_2. Each manoeuvre was continued until equilibrium was reached on the $PtCO_2$ electrode. The warm-up time for the instrument was 8.7 ± 1.1 min. It was accurate to a mean of 0.6 ± 2.1 mmHg after warming up.

Five patients undergoing elective aortic aneurysm repair and five patients scheduled for pneumonectomy or lobectomy signed informed consent to the study. The $PtCO_2$ electrode was attached prior to induction and an indwelling radial artery line was inserted. The patient's temperature, intra-arterial pressure, V5 electrocardiogram and ventilation was monitored and recorded continuously. Arterial blood gases were sampled before induction of anaesthesia, ten minutes after induction, before and after clamping of the aorta or deflation of the lung and every ½ hour thereafter. Fifty-six simultaneous measurements of $PtCO_2$ and $PaCO_2$ were obtained.

Results

The warm-up time until equilibrium $PtCO_2$ was 19.2 + 6.7 minutes in the patients. $PtCO_2$ was consistently higher than the $PaCO_2$, but the difference between the two $\Delta(PtCO_2 - PaCO_2)$ at any one time and in any one subject was not consistent.

The correlation between $PtCO_2$ and $PaCO_2$ was sought for all measurements, and the regression coefficient $r = 0.35$ ($P > 0.05$) (Figure 1).

$\Delta(PtCO_2 - PaCO_2)$ increased with time from 5 to 18 mmHg.

Thus we conclude that for intra-operative use, when wide and sudden swings in $PaCO_2$ can be anticipated, the lag time of the $PtCO_2$ sensor is too long to alert the anaesthetist so that ventilatory adjustments can be made.

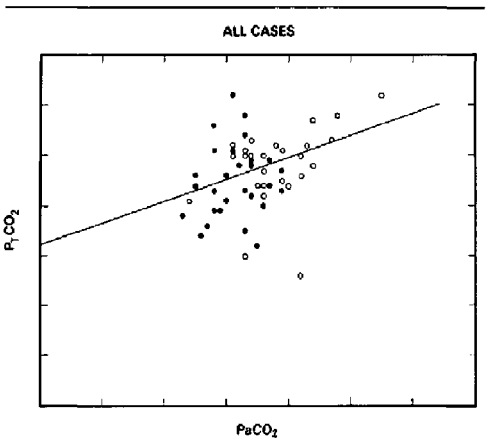


FIGURE 1

In such patients, the difference between arterial and transcutaneous PCO_2 measurements are not consistent in one patient or between patients, and it gets greater with time.

References

1 *Monaco F, Nickerson BG, McQuitty JC.* Continuous transcutaneous oxygen and carbon dioxide monitoring in the pediatric ICU. Crit Care Med 1982; 11: 765–6.

2 *Eletr S, Jimison H, Ream AK, Dolan WM, Rosenthal MH.* Cutaneous monitoring of systemic PCO_2 on patients in the respiratory intensive care unit being weaned from the ventilator. Acta Anaesth Scand 1978; 68: 123–7.

3 *McLellan PA, Goldstein RS, Ramcharan V, Rebuck AS.* Transcutaneous carbon dioxide monitoring. Am Rev Respir Dis 1981; 199–201.

4 *Goldman MD, Gribbin HR, Martin RJ, Loh L.* Transcutaneous PCO_2 in adults. Anaesthesia 1982; 37: 944–6.

Anterior chamber sulfur hexafluoride volume increase during nitrous oxide anesthesia

G.L. Wolf, C. Capuano
Department of Anesthesiology, Downstate Medical Center, Brooklyn, New York

Injection of sulfur hexafluoride (SF_6) gas into the anterior chamber of the eye during surgical repair of retinal detachment in the presence of pseudophakos has been reported to prevent anterior displacement of the lens, corneal contact, endothelial damage, and ultimate corneal opacification.[1]

We studied the effects of nitrous oxide (N_2O) anaesthesia on anterior chamber SF_6.

Cats were induced with intraperitoneal pentobarbital and acepromazine maleate, paralyzed with pancuronium, and ventilated with 66⅔ per cent N_2O, balance oxygen (O_2). Control cats were ventilated with 100 per cent O_2, and received additional doses of pentobarbital intravenously.

A forelimb vein was cannulated and 5 per cent dextrose in normal saline administered. Femoral artery cut-down and cannulation allowed continuous pressure monitoring, and intermittent blood gas determinations. Femoral vein cut-down and cannulation provided continuous venous pressure observation. Ventilation was adjusted to maintain normal end-tidal CO_2 concentration, as determined by infra-red analysis, and normal $PaCO_2$, as determined by arterial blood gas analysis.

Ventilation was maintained for at least 30 minutes prior to the injection of from 0.1–0.2 ml SF_6 gas into the anterior chamber, using a 27½ gauge needle inserted adjacent to the limbus.

Aspiration of anterior chamber gas after 30, 60 or 180 minutes (eight eyes in each of the first two groups and nine eyes in the third) allowed accumulated volume determination. Thirty-minute sampling revealed 96.25 per cent ± 16 per cent (SEM) increase in gas volume, 60-minute sampling revealed 171.25 per cent ± 16 per cent increase in gas volume, and 180-minute sampling revealed 242.22 per cent ± 22 per cent increase in gas volume. Aspiration of gas from control eyes was performed at 180 minutes and revealed 30 per cent ± 5.5 per cent increase in gas volume. The per cent change in each group was compared across all groups by one-way analysis of variance ($p < 0.001$, F Test).

The ratio of the blood/gas solubility coefficient of N_2O to SF_6 is 117, that of O_2 to SF_6 is 5.6. The difference in these ratios explains the 200 per cent difference in rate of equilibration observed between control eyes and 180 minute test eyes.

The hazard of pseudophakos posterior dislocation should be avoided by regulation of SF_6 volume and N_2O concentration when anterior chamber SF_6 is injected during retinal detachment surgery.

Reference

1 *Diddie KR, Smith RE.* Intraocular gas injection in the pseudophakic patient. Am J Ophthal, 1980; 89: 659–61.

Correlation between rapid fall in resting end-expiratory volume and onset of cerebral effects of thiopental

D. Chartrand, J. Couture
Département d'Anesthésie, Hôtel-Dieu de Montréal et Université de Montréal, Montréal, Québec

A variable and non-constant fall in functional residual capacity (FRC) has been reported during anaesthesia. This study has been designed to determine the moment of

the beginning and the duration of this fall, and also its amplitude in relation to age, obesity and pulmonary disease. The answers could lead to the understanding of the intrinsic mechanisms involved.

Methods

Two protocols were designed. In the first, a bolus of thiopental (5–7 $mg \cdot kg^{-1}$) was administered to four volunteers in the supine position. We continuously monitored the EEG (14 derivations) and the resting end-expiratory volume (REEV) with both a spirometer and magnometers, during the transition from the awake to the anaesthetized state. Magnetometers were used to partition the change in chest wall configuration between the thorax and the abdomen, and to identify eventual gas trapping. In the second protocol, REEV has been similarly monitored during induction of thiopental anaesthesia and after a subsequent injection of succinylcholine ($1.5 mg \cdot kg^{-1}$) in 18 normal patients of different ages, stature and weight, and in four patients with chronic obstructive pulmonary disease (COPD). Hyperinflations to at least 85 per cent of vital capacity (VC) were made five minutes after the stabilisation of REEV.

Results

Within 30 seconds after the injection of thiopental, we observed the beginning of the fall in REEV. The average time of completion of this fall was 11.7 ± 1.1 (SEM) seconds within a range of 3 to 24 seconds. The REEV then became stable and remained so even after the subsequent injection of succinylcholine or after hyperinflation of the lungs. In normal subjects, the Δ REEV was 452 ± 84 ml (range: 0 to 1296 ml) but, in COPD patients, it reached 1187 ± 253 ml (range: 432 to 1501 ml). This fall in REEV was unrelated to age but was correlated with obesity, evaluated by the body mass index (BMI): (Δ REEV(%VC) = 22.1 − (1.26 × BMI)). The estimations of Δ REEV with the magnetometers or with the spirometer were highly correlated and no difference could be found between them. The change in chest wall configuration associated with REEV was variable but the passive change in thoraco-abdominal configuration was the same in the awake or anaesthetized states. In the EEG group, one subject did not change his minute-ventilation with the induction of anaesthesia and his REEV remained stable. In the others, the REEV was preceeded by a ventilatory excitation phase. Two to four seconds after the beginning of this ventilatory excitation phase, we observed diffuse β waves which marked the beginning of barbiturate effects on the brain. The onset of the β waves was concommitant with the beginning of a Δ REEV in two subjects. The Δ REEV in the last subject was concommitant with the beginning of the slow Δ waves, which marked a deep anaesthetic sleep.

Discussion

The rapidity of the fall in REEV and its close relation with the appearance of the cerebral effects of thiopental, as evaluated by EEG, suggests that a depression of central control mechanisms is involved. The magnetometers showed that the passive pattern of the thoraco-abdominal volume distribution was identical in the anaesthetized and the awake state. However, the change of the chest wall configuration during the fall in REEV did not follow the passive pattern. This may suggest that an active phenomenon or the abolition of active forces occurred during the induction of anaesthesia. Because REEV did not change with the muscle relaxant, we can eliminate an increase in expiratory activity and suggest that Δ REEV is caused by the abolition of a normal active phenomenon as the inspiratory muscle tone. The fact that Δ REEV was related to obesity also favors this hypothesis. Paradoxically, COPD patients did not show any gas trapping but the largest falls in REEV. This suggests that the tonic inspiratory activity is relatively stronger in the context of decreased lung elastic recoil. Finally, the equivalence of spirometric and magnetometric evaluations of Δ REEV and the fact that REEV remained stable even after reexpansion of the lungs, both contribute to eliminate the gas trapping hypothesis.

Lidocaine and prevention of succinylcholine fasciculations and myalgia

C.P. Cole

Department of Anaesthesia, University of British Columbia, Vancouver, B.C.

Succinylcholine induced postoperative muscle pain has a reported incidence of up to 90 per cent. This myalgia may have an increased significance as a cause of anaesthetic morbidity in out-patient gynaecological surgery. These patients are generally young, healthy, ambulatory, and undergoing minor surgery, yet they have a higher incidence of postoperative muscle pain.

Various agents have been used in an effort to decrease the incidence of myalgia, including chlorpromazine, diazepam, "self-taming" doses of succinylcholine, and dantrolene. The commonest method, the use of a precurarizing dose of a non-depolarizing neuromuscular blocker is not very effective. Large, almost toxic doses of lidocaine ($6 mg \cdot mg^{-1}$ IV) have decreased muscle pain.[1]

The object of this study was to investigate the effect of a smaller dose of intravenous lidocaine on succinylcholine induced fasciculations and myalgia.

Methods

Forty patients, all ASA physical status I and II, undergoing elective, out-patient laparoscopies, were assigned

to one of four groups after informed consent was obtained. All patients received similar anaesthetic techniques: induction with thiopentone (3–5 $mg \cdot kg^{-1}$ IV) and fentanyl (1 $\mu g \cdot kg^{-1}$ IV); succinylcholine (1.5 $mg \cdot kg^{-1}$ IV); maintenance with N_2O/O_2 40 per cent, enflurane, and a succinylcholine infusion. The four groups differed only with respect to pretreatment. Group A received no pretreatment and was the control group in the study; Group B received d-tubocurare (DTC) 0.05 $mg \cdot kg^{-1}$ IV three minutes prior to induction; Group C lidocaine 2 $mg \cdot kg^{-1}$ IV one minute prior to induction; Group D received both DTC and lidocaine.

The presence or absence of fasciculations was recorded. All patients were contacted on the evening of surgery and on each of the three subsequent evenings by an investigator who was not aware of the pretreatment given. The severity of muscle pain not related to the surgical incision was graded on a scale of 0–10 by the patient and on a scale of 0–2 (none, mild-moderate, severe) by the investigator.

Results

	*Muscle pain**			
	None	*Mild-mod*	*Severe*	*Pt. Av. 0–10*
Group A-Control	2	4	4	5.0
Group B-DTC	4	2	4	5.1
Group C-Lidocaine	2	4	4	3.8
Group D-DTC + Lido	7	3	0	2.6

*Sig. Diff. ($p < 0.05$) between groups (ANOVA).

	Muscle fasciculations			
	None	*Mild-mod*	*Sev*	*Not rpt.*
Group A-Control	3	5	1	1
Group B-DTC	3	4	0	3
Group C-Lidocaine	5	5	0	
Group D-DTC + Lido	10	0	0	

Conclusion

Lidocaine, in the dose of 2 $mg \cdot kg^{-1}$ IV in combination with DTC (0.05 $mg \cdot kg^{-1}$ IV), is more effective in preventing succinylcholine-induced muscle fasciculations and pain than either of the two agents alone.

Reference

1 *Usubiaga, JE et al.* Intravenous lidocaine in the prevention of postoperative muscle pain caused by succinylcholine administration. Anesth Analg 1967; 46: 226–30.

Carbon dioxide production following coronary artery bypass surgery

F. Donati, J.G. Maillé, A. Roof, R. Blain
Institut de Cardiologie de Montréal, Montréal, Québec

Patients undergoing heart surgery under hypothermia exhibit thermal and haemodynamic instability in the immediate postoperative period. Rewarming must be accomplished at the expense of an increased oxygen consumption, which in turn causes the carbon dioxide (CO_2) production to increase. The purpose of this study was to measure variations of CO_2 production in the first six hours after heart surgery, and to correlate these variations with body temperature and haemodynamic variables.

Methods

Twenty patients undergoing elective aorto-coronary bypass grafting were anaesthetized with fentanyl 50 $\mu g \cdot kg^{-1}$, diazepam 0.2 $mg \cdot kg^{-1}$ and pancuronium 0.15 $mg \cdot kg^{-1}$. This was supplemented by halogenated anaesthetics as needed. On arrival in the recovery room, patients were ventilated with a tidal volume of 12 $ml \cdot kg^{-1}$, 10 times per minute. This frequency was adjusted as needed. End-tidal CO_2 was measured continuously for six hours with a Puritan-Bennett CO_2 analyser. Three to five arterial blood gas samples were drawn during this period. Nasopharyngeal temperature, heart rate, arterial blood pressure and pulmonary artery pressure were monitored continuously and recorded every 30 minutes.

Results

Mean end-tidal CO_2 values were 3.2 mmHg (SD ± 2.8) lower than the temperature-corrected arterial PCO_2 measurements. CO_2 production, calculated as a percentage of its value on arrival in the recovery room, increased to a mean of 285 per cent (range 165–456 per cent), and this peak occurred at a mean of 253 minutes (range 120–420) after admission to recovery room. The table shows CO_2 production (as a percentage of initial value), temperature, heart rate, systolic arterial pressure (SAP), and systolic pulmonary artery pressure (SPP), as a function of time. Time zero is at the peak of CO_2 production. Values are mean ±SEM.

Discussion

A transient but large increase in CO_2 production occurs after aortocoronary bypass surgery. This is associated with increases in temperature and heart rate. Pulmonary artery pressure increases before CO_2 production reaches its peak, and therefore may be used as a warning sign. Mechanical ventilation has to be adjusted frequently because the ventilatory drive of these patients is impaired by narcotics. Failure to do this might introduce acid–base

TABLE Postoperative measurements

Time (hours)	*−2*	*−1*	*0*
CO_2 production (%)	117 ± 4	176 ± 10	285 ± 22
Temperature (°C)	34.7 ± 0.3	35.5 ± 0.3	37.0 ± 0.3
Heart rate (min^{-1})	78 ± 3	85 ± 4	96 ± 4
SAP (mmHg)	124 ± 4	123 ± 4	125 ± 3
SPP (mmHg)	27 ± 1	36 ± 3	35 ± 2

Time (hours)	*1*	*2*
CO_2 production (%)	187 ± 13	147 ± 6
Temperature (°C)	37.8 ± 0.2	38.2 ± 0.2
Heart rate (min^{-1})	99 ± 4	101 ± 4
SAP (mmHg)	110 ± 4	117 ± 5
SPP (mmHg)	28 ± 2	29 ± 1

Time 0 = peak of CO_2 production

disorders and thus stress severely an already diseased cardiovascular system. Temperature and haemodynamic changes can direct attention to the problem of increased CO_2 production. Nevertheless, continuous end-tidal CO_2 monitoring has proved accurate and reliable in these patients.

Transcutaneous electric nerve stimulation for control of postoperative pain following spinal fusion in adolescents

G.A. Finley, D.J. Steward
Department of Anaesthesia, The Hospital for Sick Children, Toronto, Ontario

Satisfactory control of postoperative pain following major surgical procedures is still difficult to achieve, despite considerable recent progress with this problem. The use of regional analgesia techniques and epidural morphine has resulted in improved pain control, but is associated with additional complications and cannot be applied to many surgical procedures. Recently, the efficacy of transcutaneous electrical nerve stimulation (TENS) in controlling postoperative pain has been demonstrated in several studies of adult patients. We have evaluated this therapy in a group of adolescents following surgery of the spine. The study was approved by the Human Experimentation Committee and appropriate informed consent was obtained.

Twenty-two otherwise healthy patients aged 12 to 18 years scheduled for Harrington instrumentation and fusion for idiopathic scoliosis were studied. These patients were randomly assigned into 2 groups. Group I patients were given preoperative instruction in the use of the TENS unit and this was applied at the end of their operation. Group II patients served as controls and did not receive instructions or have the unit attached. The two groups were similar in age, weight, and number of vertebral levels fused. All patients received a standardized preoperative medication and anaesthesia regime. Postoperative narcotic analgesics were ordered for both groups in an identical manner: a morphine infusion was employed during the first 24 hours at a rate which was determined by the nurse to ensure patient comfort. After 24 hours, intramuscular morphine injections were ordered to be given four hourly p.r.n. The efficacy of TENS was measured by comparing morphine requirements of the two groups and by application of a subjective test (visual analogue) to determine pain levels.

TABLE I Mean morphine requirements (± SEM) ($mg \cdot kg^{-1}$ body weight)

Postop.	*Day 1*	*Day 2*
Control	0.61 ± 0.03	0.85 ± 0.05
TENS	0.52 ± 0.05	0.72 ± 0.06

Postop.	*Day 3*	*Total*	*No. of doses*
Control	0.76 ± 0.06	2.22 ± 0.13	10.0 ± 0.7
TENS	0.62 ± 0.06	1.86 ± 0.1	8.1 ± 0.55

Analysis was performed using Student's t for homogeneous data. Both the total doses of morphine and the number of doses given on the ward were found to differ at a 0.05 level of significance between TENS and control patients. Plasma morphine levels drawn at 18 to 20 hours postoperatively did not differ significantly between the groups. The mean visual analogue scores assessed at 18 to 20 hours were 6.0 ± 0.16 for three control patients and 3.7 ± 0.96 for three TENS patients (with a maximum possible pain score of 10.0). Approximately one half the TENS patients commented that they found the unit helpful or very helpful. No significant complications were reported.

This study has demonstrated that adolescents (as young as twelve years) can use a TENS unit without difficulty after a short period of instruction, that transcutaneous electrical stimulation reduces postoperative narcotic requirements in adolescents undergoing painful surgery, and that many patients express a subjective feeling of pain relief with TENS.

Effects of 100 per cent oxygen breathing on the multiple breath nitrogen wash-in curve

M. Cherry, D. Cotton
Departments of Anaesthesia and Respiratory Medicine, University Hospital, Saskatoon

The purpose of this study was to investigate the effect of breathing 100 per cent oxygen on regional ventilation in the lungs. To this end we analyzed multiple breath nitrogen wash-in curves (i.e., the rate of nitrogen increase after denitrogenation), comparing curves obtained after breathing air for 30 minutes (control period) with those obtained breathing 100 per cent oxygen for 30 minutes (study period). We reasoned that any change in regional ventilation caused by breathing 100 per cent oxygen should be reflected in a change in the rate of nitrogen wash-in compared to the control period. To make the control and study wash-in curves comparable, we measured the dilution coefficient (continuous expired volume/FRC) for each of the control and study periods and then plotted end-tidal nitrogen concentration against the dilution coefficient for the control and study periods. Continuous expired volume was measured by the volume body box during both the control and study periods and FRC was calculated from the single breath oxygen test which was done after each of the control and study periods. Results were then transferred to graphs for both the control and study periods and the two curves thus obtained were analyzed for any significant change in the rate of nitrogen wash-in. Paired t-tests were done to establish the level of significance.

Seven healthy subjects were tested – three smokers and four non-smokers. All were comparable in age, pulmonary function tests (which were normal for age/sex/size) and all had lung volumes which were normal. Respiratory histories were comparable as judged by the standard ATS (American Thoracic Society) questionnaire. All seven subjects were tested in the sitting position, and each served as his or her own control.

We found that breathing 100 per cent oxygen for 30 minutes had no adverse effect on the nitrogen wash-in curve and in fact there was a significant trend for 100 per cent oxygen breathing to cause a more rapid wash-in of nitrogen than seen after the control period, though the differences were very small. We also measured closing volume, FRC and the slope of Phase III all from the single breath O_2 test after each of the control and study periods, and then tried to correlate changes seen in these measurements with the changes found in the nitrogen wash-in curves. This analysis showed that although all three parameters changed between control and study periods, these could not be correlated with changes seen in the nitrogen wash-in curves and it was felt that the changes seen in the former were likely due to normal variation in the tests and were not significant. We conclude that breathing of 100 per cent oxygen for 30 minutes by normal subjects in the seated position has no measurable adverse effect on regional lung ventilation as reflected by the multiple breath nitrogen wash-in curve.

Isoflurane-induced hypotension does not increase pulmonary shunting or physiological dead space

J.F. Nicholas, A.M. Lam
Department of Anaesthesia, University of Western Ontario, London, Ontario

Studies by Eckenhoff have demonstrated that deliberate hypotension causes an increase in physiological dead space resulting in impairment of pulmonary gas exchange. Isoflurane has been used as a hypotensive agent with cardiovascular stability,[1] but its effects on gas exchange have not been carefully studied. We have examined the shunt fraction and physiologic dead space to tidal volume ratio before, during and following deliberate hypotension for elective clipping of cerebral aneurysms. Isoflurane was the sole agent used for induction and maintenance of hypotension in these patients.

The protocol was approved by the Human Ethics Committee, and 12 patients undergoing elective clipping of cerebral aneurysms were studied. They were divided into two groups (see Table). Group I patients were maintained with a 50 per cent O_2/air/isoflurane mixture, while Group II patients received 100 per cent O_2 isoflurane for maintenance. Preoperatively, either no premedication or diazepam by mouth was given. Anaesthesia was induced with intravenous fentanyl (up to a maximum of 2 $\mu g \cdot kg^{-1}$), thiopentone 4–5 $mg \cdot kg^{-1}$, xylocaine 1 $mg \cdot kg^{-1}$ and succinylcholine 1 $mg \cdot kg^{-1}$. All patients were ventilated via a non-rebreathing circuit with one of the two gas mixtures previously described. In all, hypotension was induced when required by increasing the inspired isoflurane concentration.

Measurements were taken after a stable period of normotension, during controlled hypotension and on return to stable normotension. During each period, inspired, mixed expired, and end-tidal gas concentrations were measured by mass spectrometry. Arterial and mixed venous blood gases, haemoglobin, and cardiac output (thermodilution) were determined, and ventilation variables were maintained constant by monitoring the expired volumes with pneumotachography.

Shunt fraction was calculated according to the standard formula and VD/VT determined from Bohr's equation. A paired t-test was used for statistical comparison between the variables measured during normotension and controlled hypotension.

Hypotension was induced smoothly and easily in all patients with isoflurane alone, from a mean B.P. of 76 ± 2 mmHg to 47 ± 2 mmHg. In both groups, the induction of hypotension did not adversely affect the shunt fraction, PaO_2, (A-a)DO_2 or VD/VT. In Group II, there was a small but significant decrease in $PaCO_2$ from 34 to 32 mmHg with hypotension. Cardiac index, heart rate, and pulmonary pressures were unchanged as previously observed.[1] Hypotension was easily reversed in all patients by decreasing the isoflurane concentration.

TABLE

	Group I (n = 6)		
	Normotension	*Hypotension*	*Recovery†*
FET Isoflurane%	1.09 ± 0.17	2.20 ± 0.16	1.11 ± 0.19
PaO_2 mmHg	200 ± 21	200 ± 23	205 ± 15
$PaCO_2$ mmHg	34 ± 1	34 ± 1	35 ± 5
VD/VT	0.39 ± 0.03	0.40 ± 0.02	0.39 ± 0.03
$\dot{V}CO_2$ ml/min	141 ± 9	141 ± 5	147 ± 5
QS/QT	0.10 ± 0.02	0.10 ± 0.01	0.09 ± 0.01

	Group II (n = 6)		
	Normotension	*Hypotension*	*Recovery‡*
FET Isoflurane%	1.23 ± 0.06	2.40 ± 0.17	1.20 ± 0.07
PaO_2 mmHg	495 ± 40	479 ± 41	447 ± 41
$PaCO_2$ mmHg	34 ± 1	32 ± 1*	32 ± 1
VD/VT	0.37 ± 0.03	0.39 ± 0.03	0.40 ± 0.02
$\dot{V}CO_2$ ml/min	152 ± 13	136 ± 10	171 ± 14
QS/QT	0.14 ± 0.02	0.14 ± 0.02	0.17 ± 0.01

*$p < 0.05$ (in comparison to normotension)
†n = 5 except VD/VT and $\dot{V}CO_2$, where n = 4
‡n = 5
All values mean ± SEM

Isoflurane was shown to be an effective agent for induced hypotension in cerebral aneurysm surgery. Shunt fraction did not increase and arterial oxygenation was not impaired. In particular, VD/VT did not increase. This was likely secondary to isoflurane's minimal effects on cardic output and maintenance of pulmonary wedge pressure.

We conclude that isoflurane offers easily obtained, reversible, and predictable hypotension with minimal pulmonary or cardiovascular derangement.

Reference

1 *Lam AM, Gelb AW.* Cardiovascular effects and gas exchange during isoflurane-induced hypotension for cerebral aneurysm surgery. Anesth Analg 1982; 61: 197.

Volume versus dopamine to maintain cardiac output as right ventricular afterload increases

D. Petkau, J.D. Kettner, L. Slykerman, L. Girling, R.M. Prewitt
Departments of Anaesthesia and Internal Medicine, University of Manitoba, Winnipeg, Manitoba

Volume expansion may be the appropriate therapy to increase cardiac output when flow is reduced because of increased right ventricular afterload. Alternatively, this therapy would increase right ventricular volumes, wall stress and right ventricular oxygen consumption and could result in ischaemia and a deterioration in ventricular performance. This study was designed to compare the effects of gradual volume expansion to continuous inotropic support on right ventricular performance, as pulmonary vascular resistance was gradually increased.

In 17 anaesthetized, ventilated dogs, we measured relevant haemodynamic parameters before and after pulmonary vascular resistance was gradually increased by glass bead microembolization of the pulmonary vascular bed. When cardiac output fell to approximately 80 per cent of baseline, dogs were randomized to treatment with volume or dopamine. When treatment increased cardiac output to 90 per cent baseline, pulmonary vascular resistance was increased further and when flow fell, the process repeated. When pulmonary vascular resistance was less than 12 $mmHg \cdot L^{-1} \cdot min^{-1}$, volume (50 ml) usually increased cardiac output but when resistance was greater, volume led to a deterioration in cardiac function ($p < 0.05$, 2 sample t-test). Mean right ventricular end diastolic pressure was only 7 mmHg when function began to deteriorate with volume. In contrast, over a similar range of pulmonary vascular resistances, dopamine consistently increased cardiac output ($p < 0.05$, paired t-test) and reduced biventricular filling pressure ($p < 0.05$, paired t-test). In addition, in five dogs treated with volume who markedly deteriorated with volume, dopamine was given. The mean results of this subset are illustrated in the Table. Note that there was a marked increase in cardiac output and stroke volume despite a reduction in biventricular filling pressures, with dopamine infusion in this setting. Using scintigraphic techniques, we confirmed that right ventricular end diastolic and end systolic volumes increased as pulmonary vascular resistance increased and further increased with volume expansion. Most likely, by increasing right ventricular wall stress and oxygen requirements, volume expansion caused right ventricular ischaemia with subsequent deterioration in performance. With volume expansion, right ventricular end systolic volume increased despite constant or reduced right ventricular end systolic pressure confirming depressed right ventricular contractility. In contrast, dopamine consistently reduced

right ventricular end diastolic and end systolic volumes. Because ventricular volumes were reduced, right ventricular wall stress and oxygen consumption may have fallen, despite increased right ventricular systolic pressure. The authors conclude that when right ventricular afterload is significantly elevated, volume may, by inducing right ventricular ischaemia, result in subtle and/or acute right ventricular dysfunction and that inotropic agents may be preferred to increase cardiac output when pulmonary vascular resistance is elevated. Also, because in this study, right ventricular function began to deteriorate with volume at a relatively low right ventricular end diastolic pressure (7 mmHg), this parameter may be a poor predictor of the response to volume when right ventricular afterload is significantly elevated.

TABLE

	CO ($L \cdot min^{-1}$)	*SV* (*ml*)	*BP* (*mmHg*)	*RVSP* (*mmHg*)
After				
Volume	2.0 ± 0.1 *	12 ± 2 *	120 ± 35 *	65 ± 6 *
Dopamine	4.0 ± 1.0	21 ± 1	177 ± 46	91 ± 8

	PVR ($mmHg \cdot L^{-1} \cdot min^{-1}$)	*RVEDP* (*mmHg*)	*LVEDP* (*mmHg*)
After			
Volume	18 ± 5	13 ± 1 *	9 ± 5 *
Dopamine	14 ± 2	9 ± 3	7 ± 4

Values are means ± standard deviation (*$p < 0.05$ paired t-test)

Supported by St. Boniface Research Foundation.

Ventilatory response to CO_2 following high dose fentanyl for aortocoronary bypass surgery: effect of nalbuphine HCl

J.G. Ramsay, B.D. Higgs, G.E. Townsend, J.E. Wynands
Department of Anaesthesia, Royal Victoria Hospital and McGill University, Montréal, Québec

It has been shown that extubation within eight hours of cardiac surgery is safe and may reduce cardiopulmonary morbidity.[1] Such "early extubation" has not been attempted in patients anaesthetized with high doses of fentanyl due to fear of respiratory depression, although the degree and duration of such respiratory depression has not been documented. In the present study the postoperative ventilatory response to CO_2 was assessed in patients who received 40 $\mu g \cdot kg^{-1}$ of fentanyl for aortocoronary bypass (ACBP) surgery. In a subgroup of patients reversal of respiratory depression with nalbuphine HCl was attempted.[2]

Methods

With informed consent and Ethics Committee approval, nine patients undergoing uncomplicated ACBP surgery were studied. All patients had good left ventricular function and no evidence of other systemic disease. The day before surgery a control ventilatory response to CO_2 was determined by the Read technique;[3] during rebreathing of 5 per cent CO_2 in 95 per cent O_2, tidal volume, respiratory rate, and end tidal PCO_2 ($PETCO_2$) were measured continuously.

Anaesthesia was induced with fentanyl 40 $\mu g \cdot kg^{-1}$ and pancuronium 0.1 $mg \cdot kg^{-1}$ and maintained with isoflurane in oxygen. Postoperatively, when patients were haemodynamically stable, responsive and normothermic, the ventilatory response to CO_2 and resting arterial PCO_2 ($PaCO_2$) were determined in those patients breathing spontaneously to a $PETCO_2 < 60$ mmHg. In patients not breathing to $PETCO_2 < 60$ mmHg, incremental doses of nalbuphine 1 mg, to a total of 10 mg were administered intravenously. All patients were extubated when $PaCO_2$ was < 50 mmHg. Response to CO_2 was assessed pre- and post-extubation and at two and four hours post-extubation. In the subsequent 12 hours respiratory rate was recorded hourly, and $PaCO_2$ measured four hourly.

Results

Curve A, Figure 1 shows averaged control CO_2 response for five patients. Curve B, 8.5 ± 0.6 hours after fentanyl administration, shows decreased slope and increased resting $PETCO_2$ compared to control. Over the following five hours (curves C and D) the slope remains depressed while resting $PETCO_2$ returns toward control.

Curve A, Figure 2 shows control CO_2 response of one patient who subsequently received nalbuphine, 10 mg, postoperatively. Curve B, 7.5 hours after fentanyl shows depressed slope and raised resting $PETCO_2$, both of which were markedly antagonized following nalbuphine (Curve C, 8.5 hours after fentanyl). The patient was then extubated. Curve D, 13.25 hours after fentanyl shows no evidence of "renarcotization".

Three additional patients made inadequate respiratory efforts at 7.85 ± 0.65 hours after fentanyl (spontaneous $PETCO_2 > 60$). Nalbuphine, 10 mg resulted in spontaneous respiration to an elevated $PaCO_2$ (10–15 per cent above control); the slope of the CO_2 response was similar to control. All three patients were then extubated.

No patients required reintubation and no respiratory or

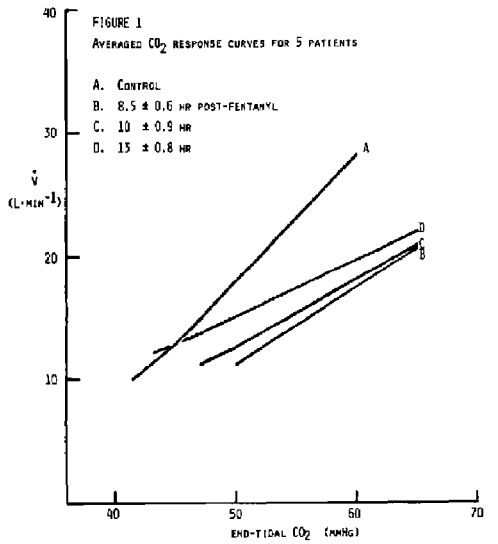


FIGURE 1 Averaged CO_2 response curves for five patients.

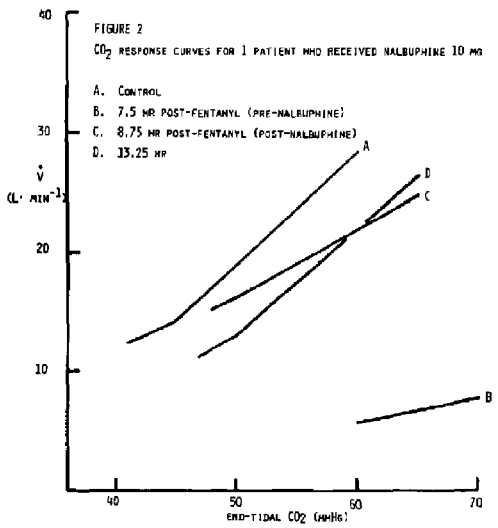


FIGURE 2 CO_2 response curves for one patient who received nalbuphine 10 mg

cardiovascular deterioration occurred post-extubation. Patients who received nalbuphine experienced slight incisional discomfort and a rise in blood pressure of 15 to 30 per cent during drug administration. Three of four patients receiving nalbuphine experienced nausea at some time in the subsequent 12 hours which was treated with droperidol 1.25 mg intravenously.

Discussion

The findings indicate that some but not all patients receiving 40 $\mu g \cdot kg^{-1}$ of fentanyl for ACBP surgery can be extubated approximately eight hours after fentanyl administration, without requiring a narcotic antagonist. These patients may breathe to an acceptable $PaCO_2$ or $PETCO_2$ but will have a depressed response to raised PCO_2. There is considerable inter-patient variability in both control and postoperative response to CO_2, and patients should be individually assessed and carefully monitored should early extubation with or without nalbuphine be employed.

References

1 *Quasha AL, Loeber N, Feeley TW, Ullyot DJ, Roizen MF.* Postoperative respiratory care: A controlled trial of early and late extubation following coronary-artery bypass grafting. Anesthesiology 1980; 52: 135–41.

2 *Magruder MR, Delaney RD, Difazio CA.* Reversal of narcotic induced respiratory depression with nalbuphine hydrochloride. Anesthesiology Review; In Press.

3 *Read DJC.* A clinical method for assessing ventilatory response to CO_2. Aust Ann Med 1967; 16: 20–32.

Stability of carbonated lidocaine

M. Soderman, P.C. Duke
Department of Anesthesia, University of Manitoba, Winnipeg, Manitoba

Carbonated lidocaine (Li-CO_2) is used commonly in Canada because of its apparent clinical superiority over lidocaine hydrochloride in terms of its speed of onset, intensity and reliability of block.[1] It has been suggested this superiority is due to the contained CO_2 and its effect on intraneural pH and nerve conduction. The manufacturer recommends that only freshly opened vials be used and that the agent be drawn into syringes by slow aspiration through only large bore cannulae. The necessity for these recommendations has not been previously established. This study attempts to answer two questions:

1 How quickly does CO_2 leave undisturbed open vials of Li-CO_2?

2 What is the effect of rapid aspiration through a small needle on the CO_2 content of Li-CO_2?

The pH of Li-CO_2 in undisturbed open vials increased from an initial value of 6.51 ± 0.01 (mean ± S.D.) at the time of opening to a value of 6.96 ± 0.02 at three hours. Corresponding calculated values for PCO_2 were 600 torr at opening and 192 torr at three hours (see Table I). Precipitation of Li-CO_2 base had occurred in all vials after three and one half hours of exposure to atmospheric conditions. Precipitation was caused by the increased concentration of Li-CO_2 base resulting from the loss of CO_2 and higher pH.

The rapid aspiration of Li-CO_2 through a 25 gauge one and one half inch needle resulted in a significant ($p < 0.05$) increase in measured pH, (6.61 vs 6.51), when compared to slow aspiration through a 16 gauge needle of similar length. The corresponding difference in calculated PCO_2 was 600 torr for "slow aspiration" versus 471 torr for "rapid aspiration" (see Table II).

In conclusion, Li-CO_2 is relatively stable with a half time for loss of CO_2 of approximately two hours. In addition, there is a loss of CO_2 which results from rapid aspiration through a small needle. Although the increased efficacy of Li-CO_2 is due in part to contained CO_2, it may be explained by more rapid *in vivo* buffering of the injected solution towards physiological pH. CO_2 diffuses out of the drug *in vivo*, raising the environmental pH and thus increasing the percentage of the un-ionized base that is available for diffusion intracellularly.

TABLE 1 Solution in open vials (n = 3)

Time (hours)	*pH at 25° C*	*PCO_2 (torr)*
0.0	6.51 ± 0.01	600
0.5	6.54 ± 0.02	558
1.0	6.61 ± 0.04	471
1.5	6.65 ± 0.05	417
2.0	6.81 ± 0.03	288
2.5	6.91 ± 0.04	224
3.0	6.97 ± 0.02	192
3.5	precipitated	

TABLE 2 Aspiration of Solution (n = 4)

	Slow aspiration 16 gauge 1½" needle	*Fast aspiration 25 gauge 1½" needle*
pH mean ± S.D.	6.51 ± 0.02	6.61 ± 0.03
calculated PCO_2	600	471

Reference

1 *Bromage PR.* Carbonated local anesthetics. Can Med Assoc J 1967; 97: 1377–84.

Epidural morphine in obstetrical analgesia: effect of epinephrine addition

R. Martin, J.P. Tétrault, L. Tétreault, Y. Lamarche, L.J. Veilleux

Département d'anesthésie, Centre hospitalier universitaire de Sherbrooke, Sherbrooke, Québec.

Several studies have shown the effectiveness of epidural morphine in acute and chronic pain, but in obstetric analgesia failures were often reported. A mechanism invoked by some authors in the increased absorption of morphine in the pregnant patient. To test this hypothesis, we studied in a double blind manner the effect of epinephrine addition to a morphine sulfate solution and looked for possible interaction between morphine and bupivacaine.

Informed consent was obtained from 75 ASA physical status I primigravida patients. According to a random number table, they were divided into five groups of 15 patients. With labour well under way and when analgesia was called for, a continuous epidural using a standard technique was administered; Group I received a 10 ml solution containing: morphine sulfate 2 mg with epinephrine 1/200,000 in 0.9 NaCl; Group II: morphine sulfate 2 mg and bupivacaine 25 mg; group III: morphine sulfate 2 mg, bupivacaine 25 mg and epinephrine 1/200,000; Group IV: bupivacaine 25 mg; and Group V: bupivacaine 25 mg and epinephrine 1/200,000. A 10 cm pain relief analogue scale was used to measure the analgesic effect. Side effects were looked for and duration of analgesia determined. Analysis of variance was used for the quantitative results and a non-parametric Chi square test for the side effects. The significance level was $p < 0.05$.

The 75 patients were found to be comparable with regards to age, pain before epidural injection, cervical dilatation, blood pressure, duration of labour. Group I patients (morphine and epinephrine) had significatively less pain relief ($p < 0.001$) than the other four groups who were equally relieved. The time between the first epidural injection and reinjection was significatively shorter ($p < 0.001$) in Group I; in the other groups, only Group II vs Group IV showed a difference in that respect, time being longer for Group II. Patients who received morphine had significatively more nausea and pruritus than patients not receiving morphine.

We concluded that epinephrine is not effective with a small dose of morphine (2 mg) in obstetrical epidural analgesia and that the combinations bupivacaine-morphine and bupivacaine-morphine-adrenaline do not present any advantage that would justify their use instead of bupivacaine alone.

Plasma fibronectin during cardiopulmonary bypass

A.W. Gotta, S. Carsons, L. Abrams, C. Sullivan
Department of Anesthesiology, State University of New York, Downstate Medical Center, Brooklyn, New York

Plasma fibronectin is an opsonin, marking particulate matter for phagocytosis by the reticuloendothelial system. We have studied the effects of cardiopulmonary bypass on plasma fibronectin levels.

Methods

After obtaining informed consent, nine patients undergoing coronary artery bypass were anaesthetized with fentanyl intravenously, and isoflurane in oxygen, by inhalation. The pump was primed with one liter normal saline and one liter 5 per cent dextrose in water. The prime was cooled to 5–10° C before bypass, and the patient was cooled to 20–22° C after bypass was started. Heparin 3 $mg \cdot kg^{-1}$ was administered intravenously prior to bypass. Blood was drawn (1) after the administration of heparin, but before bypass (baseline); (2) 5 minutes after bypass; (3) mid bypass; (4) immediately prior to coming off bypass; (5) off bypass, but before administration of protamine. Plasma fibronectin levels were determined by rocket electrophoresis, using monospecific serum. As an index of dilution plasma albumin levels were determined by radial immunodiffusion. Deviations from baseline were tested for significance using Student's t test.

Results

Plasma fibronectin levels decreased significantly immediately after beginning cardiopulmonary bypass, then gradually rose during bypass, but did not reach baseline levels (Table). Serum albumin levels also decreased significantly, reaching a maximal decline of 35 per cent, as contrasted to a maximal 59 per cent for fibronectin. The decline in fibronectin levels was significantly greater than the decline in albumin levels ($p < 0.02$).

Discussion

Decreased levels of fibronectin have been associated with intravascular aggregation of particulate matter, altered regional perfusion, increased V_D/V_T, increased susceptibility to bacterial infection and multiple organ failure. Plasma fibronectin apparently forms an interchangeable pool with cell-surface fibronectin, depletion of which may decrease vascular integrity and lead to extravascular sequestration of "third space" fluid. The demonstrated decrease in fibronectin levels may be due to dilution, cold precipitation, increased opsonic activity, or trapping within the pump filters or tubing. The fibronectin deficit may be corrected by the administration of cryoprecipitate which contains cold insoluble globulin, antigenically similar to fibronectin.

TABLE

Time	*Mean fibronectin level $\mu g \cdot ml^{-1}$ (± SEM)*
Pre-pump	435 (51.7)
Immediately after starting bypass	177 (28.6)*
Mid-bypass	255 (29.6)†
Prior to ending bypass	313 (30.9)‡
Off bypass	292 (25.5)‡

*$p < 0.001$. †$p < 0.01$. ‡$p < 0.025$.

Pancuronium requirements during hypothermic cardiopulmonary bypass in man

M.E. Futter, D.R. Whalley, J.E. Wynands, D.R. Bevan
Department of Anaesthesia, Royal Victoria Hospital and McGill University, Montréal, Québec

The dose requirements of drugs producing neuromuscular block (NMB) during operations involving cardiopulmonary bypass (CPB) have received little attention due in part to the traditional practice of ventilating patients postoperatively until cardiovascular stability is assured. Previous studies have focused on the qualitative changes of NMB associated with hypothermia and CPB. This study was undertaken to investigate and quantitate the pancuronium requirements to maintain constant NMB in man during hypothermic CPB.

Methods

Institutional approval was obtained and eight patients undergoing cardiac surgery were studied. Premedication consisted of oral diazepam (7.5–10 mg) and intramuscular morphine (5–10 mg) and hyoscine (0.3–0.4 mg). Anaesthesia was induced with fentanyl (40–80 $\mu g \cdot kg^{-1}$). The ulnar nerve was stimulated at the elbow with subcutaneous needles by "train-of-four" impulses using a Grass S48 stimulator and SIU5 isolation unit. Contraction of adductor pollicis muscle was measured with a Grass FT10 force displacement transducer and recorded on a Grass polygraph pen and ink recorder. After control recordings pancuronium (0.063–0.089 $\mu g \cdot kg^{-1}$) was given to facilitate intubation and a pancuronium infusion begun to maintain T1 at 5–15 per cent of control. Normocapnia was maintained. Anaesthesia was supplemented by nitrous oxide, droperidol or additional fentanyl as necessary. The nasopharyngeal and thenar skin temperatures were monitored as well as direct radial artery and pulmonary artery pressures, arterial blood gas tensions, ECG, serum potassium concentrations and

urinary output. The pancuronium requirements of each patient were assesed during five periods: (1) normothermia, pre-CPB; (2) initiation of CPB and cooling; (3) steady hypothermia on CPB; (4) rewarming; (5) normothermia, where both nasopharyngeal and skin temperatures were similar to those in period 1. Data were analysed using paired Student's t test and Wilkinson's ranked sign test for pairs.

Results

The average age of seven males and one female was 59 years (range 50–66 years) and average weight 68.5 kg (range 49–92 kg). The infusion durations, mean temperatures and infusion rates during the five periods of the pancuronium infusion are shown in the table.

Discussion

We found that the combination of an infusion and continuous monitoring of the neuromuscular junction allows a constant level of NMB to be maintained because the rate of infusion can be adjusted rapidly to match changing drug requirements. The increased infusion rate during the first five to ten minutes of CPB presumably counteracted the diluting affect of the pump prime. There was an 84 per cent decrease in NMB drug requirement during hypothermic CPB probably as a result of decreased clearance and increased sensitivity of neuromuscular junction. An increased rate of infusion of pancuronium was required during rewarming to counteract the increased clearance and to re-establish an effective plasma concentration. At normothermia, after CPB, pancuronium requirements were significantly less than pre-CPB. Causes may include incomplete rewarming of the muscle, a nonsteady state pre-CPB and most likely, decreased renal and hepatic clearance of pancuronium immediately after CPB.

TABLE

		Temperature (°C)		
Period	*Duration (min)*	*Naso-pharyngeal*	*Skin*	*Pancuronium infusion rate ($\mu g \cdot kg^{-1} \cdot min^{-1}$)*
1 Pre-CPB	38 ± 9	35.2	29.2	0.52 ± 0.057
2 Initiation CPB and cooling	24 ± 4	—	—	0.62 ± 0.136
3 Hypothermia on CPB	32 ± 5	26.2	26.8	0.083 ± 0.012*
4 Rewarming	42 ± 5	—	—	0.64 ± 0.060†
5 Normothermia post CPB	34 ± 9	36.7	31.9	0.33 ± 0.083‡

*Significantly less than all other periods. $P < 0.05$–<0.001.
†Significantly greater than periods 3 and 5. $P < 0.001$ and $P < 0.01$.
‡Significantly less than periods 1, 2 and 4. $P < 0.05$–<0.01.

References

1 *Park WY, MacNamara TE.* Temperature change and neuromuscular blockade by d-tubocurarine or pancuronium in man. Anesthesiology 1979; 50: 161–3.
2 *Shanks CA, Walker.* Cardiopulmonary bypass alters d-tubocurarine pharmacokinetics. Anesthesiology 1982; 57: A279.

Effects of increased viscosity on right ventricular function when pulmonary vascular resistance is elevated

M. Ghignone, R.M. Prewitt, M. Razen, L. Girling, L. Slykerman
Department of Anesthesia, Health Sciences & University of Manitoba, Winnipeg, Manitoba

In patients with acute respiratory failure packed red blood cells have been recommended as therapy to increase arterial oxygen content, cardiac output and oxygen tissue delivery. Despite this recommendation, effects of such therapy on right ventricular performance in the setting of elevated pulmonary vascular resistance have not previously been investigated.

We studied the effect of an increased haematocrit (HCT) on right ventricular performance in 12 anaesthetized, ventilated dogs (FiO_2 1.0). Acute respiratory failure and pulmonary hypertension were induced by microembolization of the pulmonary microvasculature with glass beads (70–100 μ). Arterial and venous blood samples and relevant haemodynamic parameters were measured before (HCT 25) and after (HCT 42) isovolemic exchange transfusion with packed red blood cells. To control for time, final measurements were obtained following haemodilution to reduce haematocrit to control level. In addition, to determine effects of increased viscous load on right ventricular (RV) pressure-flow characteristics, in 6 open-chested dogs, peak flow ($\dot{V}$ ml·sec^{-1}) and peak acceleration of ejected blood ($\ddot{V}$ ml·sec^{-2}) were measured under the same conditions. Mean results ± SD are shown in Table.

Corresponding to the rise in HCT there was a large reduction ($p < 0.01$) in cardiac output (CO) and stroke volume (SV), peak flow ($\dot{V}$) and maximum acceleration ($\ddot{V}$). These changes occurred despite a small but significant increase in right ventricular end diastolic pressure (RVEDP) ($p < 0.01$) and a large increase in right ventricular end diastolic volume, confirmed in three

TABLE

	Baseline HCT 25%	*HCT 42%*	*Time control HCT 25%*
CO $L \cdot min^{-1}$	2.4 ± 0.6	1.5 ± 0.5*	2.2 ± 1
SV $ml \cdot min^{-1}$	14 ± 5	9 ± 4*	15 ± 6
RVEDP mmHg	4 ± 2	5.5 ± 2.5*	3.8 ± 2
PAP mmHg	31 ± 4.5	33 ± 5	32 ± 5
BP mmHg	111 ± 26	110 ± 26	111 ± 25
PVR mmHg· $L^{-1} \cdot min^{-1}$	10.5 ± 2	18.5 ± 2*	11 ± 2
$\dot{V}$ $ml \cdot sec^{-1}$	455 ± 307	277 ± 245*	470 ± 321
$\dot{V}$ $ml \cdot sec^{-2}$	5352 ± 2613	3023 ± 2312*	5256 ± 2349
O_2 transport $ml \cdot min^{-1}$	280 ± 20	281 ± 15	276 ± 24

*$p < 0.01$

animals with equilibrium nuclear angiographic technique. Since pulmonary artery pressure (PAP) and contractility as assessed by V max were similar, the reduction in flow with increased haematocrit is not due to depression is contractility but is explained by the increase in pulmonary vascular resistance (PVR) ($p < 0.01$). Since, with time, all parameters returned to baseline the increase in resistance was not due to reduction in cross sectional area, but to increased viscosity. Despite the increase in haematocrit and arterial oxygen (O_2) content, tissue oxygen delivery did not increase with packed red cell transfusion, because flow fell. We conclude that when resting pulmonary vascular resistance (PVR) is elevated changes in haematocrit within physiological range may significantly depress cardiovascular performance so that despite increased arterial oxygen tissue oxygen delivery may not increase.

Lung water measurements in the presence of pulmonary emboli and PEEP

J.C. Kay, W.H. Noble
Department of Anaesthesia, St. Michael's Hospital and University of Toronto, Toronto, Ontario

Extravascular lung water volume is being assessed with double indicator dilution techniques. However, up to now, because of a lack of commercially available monitoring equipment, the technique has not had wide acceptance. Recently, however, an automated microcomputer system that uses heat as the diffusible indicator, analyses the curves automatically, calculates the extravascular thermal volume, then gives a digital display of the results, has become available commercially. Although this will undoubtedly increase the popularity of the ETVL measurement, the limits of the thermal dilution technique still need to be defined over a wide range of conditions.

Two factors which will affect the diffusion of heat are blood flow, and bloodflow distribution. Therefore, in this study we evaluated the effects in dogs of fluid overload, pulmonary microemboli and ventilation with PEEP, on lung water determinations, by comparison with a gravimetric analysis of the excised lungs.

Methods

Our technique to assess extravascular thermal volume uses 3 per cent saline at room temperature. Heat is the diffusible indicator, and sodium ions producing changes in blood conductivity act as the intravascular indicator.

Mongrel dogs weighing 17–35 kg were anaesthetized with pentobarbitone 30 $mg \cdot kg^{-1}$. The trachea was intubated, and the dogs allowed to breathe room air spontaneously, or were ventilated with 15 cm H_2O PEEP.

The extravascular thermal volume of the lung was determined just before removing the lungs for gravimetric determination of the pulmonary extravascular tissue weight (PETW). There were 3 groups of dogs: A group of 35 dogs were overloaded with Dextran (overload group). Two other groups received starch emboli (63–74 μ in diameter) suspended in normal saline ($0.125\ g \cdot kg^{-1}$). Twenty five dogs received emboli alone (emboli group) and 20 dogs received emboli and were then ventilated with 15 cm H_2O PEEP (emboli + PEEP group).

The ratio of ETVL/PETW was compared in the three groups. Results are expressed as the mean ± SEM.

Results

The ETVL/PETW ratio was 1.60 ± 0.06 in the volume overload group, 1.43 ± 0.08 in the emboli group and in the emboli + PEEP group 1.17 ± 0.06. There was no significant difference between the volume group and the emboli group. However, the ratio in the emboli + PEEP group was significantly lower than in the other two groups ($p < 0.01$).

Discussion

The fact that ETVL/PETW ratio of 1.43 after emboli was not significantly different from the ETVL/PETW ratio of 1.60 in the volume overload dogs suggests heat is transferred into the embolized areas from adjacent perfused vessels. The dogs in the emboli plus PEEP group showed a significant reduction in the ETVL/PETW ratio 1.17. This may indicate a decrease in surface area for heat exchange due to collapse of vessels distal to emboli, due to the application of PEEP. Whilst the reasons for this decrease in ETVL/PETW ratio must remain conjectural, clinicians should be aware that there is a potential for underestimating lung water in the presence of pulmonary emboli and the application of PEEP.

Effects of lidocaine on hypoxic pulmonary vasoconstriction in dogs

R. Kozody, F. Cheney
Departments of Anesthesia, University of Washington, Seattle, Washington, and University of Manitoba, Winnipeg, Manitoba

Lidocaine is commonly used both as an antiarrhythmic and local anaesthetic agent. The effects of lidocaine on the heart and systemic vasculature have been well documented, while its effects on the pulmonary vasculature have not. Patients receiving lidocaine may have underlying pulmonary gas exchange abnormalities with areas of regional hypoxaemia and resultant hypoxic pulmonary vasoconstriction (HPV). Important changes in HPV and venous admixture may occur when lidocaine is administered. This study was undertaken to determine the effect of lidocaine on pulmonary vascular resistance (PVR) and venous admixture (Q_{va}/Q_t), under normoxic and hypoxic conditions in experimental animals.

Methods

Seven mongrel dogs weighing 15–25 kg were anaesthetized with intravenous pentobarbital, intubated, paralyzed with pancuronium and ventilated to maintain $PaCO_2$ between 30–35. Each dog then underwent three ten-minute hypoxic challenges with an inspired O_2 (FiO_2) = 0.10 with a return to FiO_2 = 0.30 for ten minutes between challenges. After the third challenge, lidocaine was infused at 1 $mg \cdot kg^{-1} \cdot min^{-1}$ and continued for 30 minutes. At ten-minute intervals, three hypoxic challenges were repeated. Cardiac output and other relevant haemodynamic parameters were measured. After stabilization at each FiO_2 venous admixture was calculated. Arterial blood was drawn for lidocaine levels at ten-minute intervals in three of the seven dogs studied.

Results

Mean results are reported in the Table.

TABLE

	Qt ($L \cdot min^{-1}$)	*PAP* (*mmHg*)
Pre lidocaine		
Normoxia	3.14 ± 1.11	12 ± 2
Hypoxia	4.47 ± 1.6*	31 ± 6*
Post lidocaine		
Normoxia	3.49 ± 1.6	16 ± 3
Hypoxia	4.15 ± 1.7	34 ± 5*

	PVR (*dyne.sec·cm*$^{-5}$)	Q_{va}/Q_t
Pre lidocaine		
Normoxia	288 ± 89	6 ± 2%
Hypoxia	559 ± 158*	1 ± 0.6%*
Post lidocaine		
Normoxia	297 ± 80	6 ± 3%
Hypoxia	668 ± 249*	1 ± 1%*

*$p < 0.05$ compared to normoxia. Values are ± S.D.

Conclusion

Lidocaine had no significant effect on Qt, PVR and Q_{va}/Q_t in dogs at serum levels as high as 15.9 ± 1.9 $\mu g \cdot ml^{-1}$ during normoxia. Hypoxaemia significantly increased PVR and PAP, and significantly decreased Q_{va}/Q_t when compared to normoxic conditions. Q_t, PAP and PVR were unaffected by lidocaine during hypoxia. Q_{va}/Q_t was not increased with the infusion of lidocaine. It therefore appears that lidocaine does not have any clinically significant effect on HPV and can be safely administered therapeutically when required in patients with pulmonary gas exchange problems.

Effects of volatile anaesthetics on tracheal mucociliary transport

J.B. Forrest, C. Chambers
Department of Anaesthesia, McMaster University, Hamilton, Ontario

Volatile anaesthetics have been implicated in postoperative depression of mucociliary transport (MCT). The effects of enflurane, halothane, isoflurane and methoxyflurane at one and two MAC in humidified O_2 (95 per cent) CO_2 (5 per cent) were tested using an isolated rabbit tracheal preparation maintained at 37° C. MCT was measured under direct vision in a microscope as the rate of movement of carbon particles deposited on the mucosal surface, prior to, during (30 min) and after exposure to each agent from a calibrated vapourizer. MCT was measured every five minutes.

Each of the agents caused a significant increase in MCT above baseline values, within five minutes after exposure at either concentration. After 30 minutes exposure, enflurane at one MAC caused MCT to increase to 42 per cent and at two MAC to 28 per cent above baseline values, averaged for six animals. The values for one and two MAC after 30 minutes for halothane were 19 and 28 per cent, for isoflurane were six and 17 per cent and for methoxyflurane were 29 and 33 per cent respectively above baseline values. After exposure, MCT at 15

minutes for the one and two MAC groups were for enflurane nine and eight per cent, halothane 10 and 10 per cent, isoflurane six and seven per cent and methoxyflurane 15 and 28 per cent respectively, above baseline (pre-exposure) values. The increases during exposure were significantly higher than baseline values at $p = 0.01$ for each agent up to 20 minutes but for isoflurane at 30 minutes at one MAC, the increase was not significant. Recovery of MCT to near baseline values was rapid in each case except methoxyflurane. Total mucus production was measured in every case and paralleled the increases quoted for MCT. The effects of the same concentrations on isolated ciliated cells did not show any alteration in beat frequency. On the other hand, use of non-humidified gas caused MCT to cease. It is concluded that all agents cause increased mucus production without altered ciliary beat frequency and that this leads to an overall increase in MCT which recovers promptly after exposure. It is likely that the use of non-humidified gases is more important in causing postoperative depression of mucociliary transport.

High frequency ventilation does not depress respiratory cilia function

J.B. Forrest, C. Chambers
Department of Anaesthesia, McMaster University, Hamilton, Ontario

Ventilation by high frequency oscillation has been shown in animals and humans to be effective in maintaining adequate gas exchange. The effects of high frequency ventilation (HFV) on ciliary beat frequency are unknown. Isolated rabbit tracheas and intact rabbits anaesthetised with pentobarbital as well as isolated ciliated cells were subjected to HFV using humidified 95 per cent O_2 and 5 per cent CO_2, at 1, 3, 4, 5, 6, and 10 Hz, for 1 hour. Ciliary beat frequency was measured using a video motion analyser attached to a Heitz light microscope before and after HFV. In each model, HFV did not significantly alter ciliary beat frequency at oscillations of 1, 3, 4, or 10 Hz. where mean beat frequencies (± SE) before HFV were 13.3 ± 1.5, 12.2 ± 0.7, 13.4 ± 0.6 and 13.4 ± 0.9 Hz respectively and after HFV were 13.1 ± 1.5, 12.5 ± 0.8, 13.5 ± 0.5 and 13.5 ± 0.5 Hz respectively. At 5 and 6 Hz oscillations, HFV caused a significant increase in cilia beat frequency from 12.7 ± 0.5 to 13.6 ± 0.5 Hz and 12.8 ± 0.4 to 13.7 ± 0.5 Hz respectively at the 5 per cent significance level. HFV of intact rabbits using dry gas (95 per cent O_2 in 5 per cent CO_2) resulted in marked depression of ciliary beat frequency at all oscillatory frequencies and to the same extent. The overall mean pre-HFV beat frequency using dry gas was 12.1 ± 0.7 Hz and after 1 hour of HFV was 3.2 + 0.6 Hz. After 30 minutes (following HFV with dry gas) during which humidified gas was used, there was only partial recovery of beat frequency (5.7 ± 0.8 Hz).

It is concluded that the use of HFV up to 10 Hz does not depress ciliary beat frequency when humidified gases are used. A significant increase in beat frequency occurred at 5 and 6 Hz HFV and it is suggested this is an optimum frequency. Compared to optimum frequencies for airway pressure of 10 Hz and for maintenance of gas exchange of 15 Hz. The use of dry gases for ventilation significantly lowered ciliary beat frequency.

Expiratory work during halothane and isoflurane anaesthesia

F. Carli, B.D. Higgs
Department of Anaesthesia, Royal Victoria Hospital and McGill University, Montréal, Québec

During spontaneous respiration, the smooth transition from inspiration to expiration is effected by a braking effect of the inspiratory muscles, known as post-inspiratory muscle activity. The duration and measurement of this activity has been described.[1,2] During inspiration, elastic energy is stored to overcome the pressure exerted by the antagonistically contracting inspiratory muscles (PmusI) and the flow resistance (Pres) to expiration. The mechanics of ventilation are affected by inhalation anaesthetic agents but the work required to match these changes has not been measured. This study was designed to measure the amount of work done during expiration in overcoming PmusI and Pres during halothane and isoflurane anaesthesia.

Methods

Ten unpremedicated patients (ASA 1), matched for age and surface area, were studied. Anaesthesia was induced and maintained with halothane (one MAC)-oxygen (five subjects) or isoflurane (one MAC)-oxygen (five subjects). Post-inspiratory muscle activity was measured quantitatively by comparing flow-volume loops obtained during spontaneous breathing and relaxed expirations. The work done by the inspiratory muscles during spontaneous expiration (WmusI) was computed according to Rahn's Diagram as the difference between the expiratory flow-resistive work (Wres) and the total elastic work (Wel) available in the system for expiration.

Results

During halothane anaesthesia, post-inspiratory muscle activity persisted for 74 per cent of expiration. The rate of decay is shown in Figure 1. During isoflurane anaes-

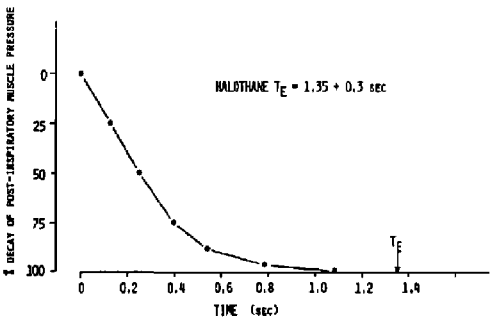


FIGURE 1

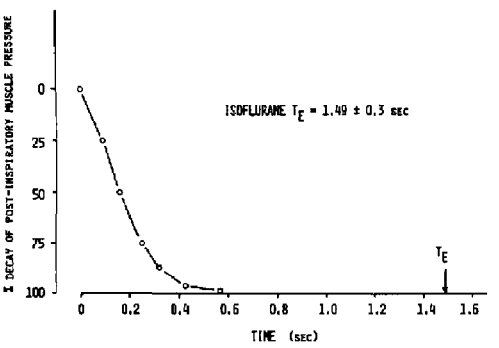


FIGURE 2

thesia, post-inspiratory muscle activity persisted for 47 per cent of expiration. The rate of decay is shown in Figure 2. The average total expiratory work (Wel), the antagonistic work of the inspiratory muscles (WmusI) and the work required to overcome flow resistance (Wres) during halothane and isoflurane anaesthesia are tabulated below. The amount of energy expended per minute (Wel × respiratory rate) was calculated.

	Wel (Joules)	*Wmusl (%) (Joules)*	*Wres (%) (Joules)*	*Wel/min (Joules/min)*
Halothane	0.25	0.15 (58%)*	0.10 (42%)*	5.9
Isoflurane	0.33	0.13 (38%)*	0.20 (62%)*	6.1

*$p < 0.05$

Conclusion

Post-inspiratory muscle activity is prolonged with both anaesthetic agents, the decay is slower and the duration longer with halothane.

The same amount of work (Wel) is performed per minute with both anaesthetic agents but the resistive component is greater with isoflurane (62 per cent) and the antagonistic inspiratory muscle component is greater with halothane (58 per cent).

References

1 *Agostoni E, Citterio G.* Relative decay of inspiratory muscle pressure and breath timing in man. Respir Physiol 1979; 38: 355.

2 *Behrakis PK, Higgs BD, Baydur A, Zin WA, Milic-Emili J.* Respiratory mechanics during halothane anaesthesia and anaesthesia-paralysis in man. J Appl Physiol. In press, 1983.

Epidural fentanyl does not cause delayed respiratory depression

A.M. Lam, R.L. Knill, W.R. Thompson, J.L. Clement, G.P. Varkey, W.E. Spoerel

Department of Anaesthesia, University Hospital and University of Western Ontario, London, Ontario

Epidural morphine, although an effective method of pain relief, is associated with undesirable side-effects, the most serious of which is delayed respiratory depression.[1] The occurrence of segmental analgesia in combination with delayed respiratory depression, nausea and vomiting, suggests that the latter effects were caused by the cephalad spread of morphine in the cerebrospinal fluid. The poor affinity for lipid tissues presumably has allowed morphine to persist in the cerebrospinal fluid to migrate rostrally. If this is correct, then a more lipophilic agent like fentanyl should have fewer undesirable effects. In this study, we evaluated this hypothesis by assessing the respiratory and analgesic effects of subcutaneous and epidural fentanyl in a double-blind manner.

Five informed, healthy volunteers participated in this study. In a randomized sequence, each subject was studied four times: (1) after intramuscular fentanyl 100 μg, (2) after intramuscular placebo (saline), (3) after epidural fentanyl 100 μg and (4) after epidural placebo (saline). Respiratory and analgesic effects were measured at times 0, 30, 60, 90, 120, 150, 240, 360, 540, 720 minutes and at the end of 24 hours. The respiratory measurement consisted of resting ventilation, end-tidal PCO_2 as determined by mass spectrometry, and the ventilatory response to added CO_2 using the modified Read's rebreathing method. Analgesic effect was assessed by determining the ischaemic time tolerated by the subject after submaximal exercise with a tourniquet placed on the thigh.

	0 min	30 min	60 min	90 min	150 min
Analgesic Time (sec)					
Epidural					
Fentanyl	134 ± 15	400* ± 99	348* ± 99	329* ± 61	259* ± 31
Placebo	146 ± 46	203 ± 42	147 ± 32	218 ± 48	156 ± 26
CO_2 Response Slope ($L \cdot min^{-1} \cdot kPa^{-1} \cdot m^{-2}$)					
Epidural					
Fentanyl	10.9 ± 2.1	7.9 ± 1.9	9.9 ± 1.9	10.9 ± 2.3	9.2 ± 1.6
Placebo	11.5 ± 1.7	10.2 ± 2.3	10.4 ± 2.0	11.2 ± 1.4	10.8 ± 1.7

n = 5; all values means ± SEM; within analysis of variance.
*Significantly different from control $p < 0.05$.

Other than minor backache experienced by one subject, no complication resulted from the study. Specifically, there was no urinary retention, itching, nausea or vomiting. Using analysis of variance, analgesic time was significantly prolonged by epidural fentanyl for up to 150 minutes ($p < 0.05$). The intramuscular route appeared to provide some analgesia at 30 minutes, but no significant difference from control or placebo could be demonstrated. Neither epidural nor intramuscular placebo had any consistent effect on analgesic time. Irrespective of the route of administration or drug (placebo) administered, resting ventilation, end-tidal PCO_2 and CO_2 response remained normal throughout the time periods and no significant difference could be demonstrated between the groups. We conclude that the epidural administration of the short-acting, lipophilic narcotic fentanyl may provide adequate analgesia without undesirable side-effects.

Reference

1 *Knill RL, Clement JL, Thompson WR.* Epidural morphine causes delayed and prolonged ventilatory depression. Can Anaesth Soc J 1981; 28: 537–43.

Thiopental bolus before clamping during carotid endarterectomy – rational drug therapy?

J.A. Moffat, M. McDougall, D. Spence, F. Saunders, E.S. Shelley, F.W. Cervenko, D. Brunet, B. Milne
Department of Anaesthesia, Hotel Dieu Hospital & Queen's University, Kingston, Ontario

The mechanism by which barbiturates produce cerebral protection and the dose required for this effect remain controversial. However, a relationship has been shown between cerebral metabolic rate and duration of EEG burst suppression with thiopental dosing in dogs[1] and EEG burst suppression has been used as a therapeutic endpoint in patients.[2] In practice, during carotid endarterectomy a thiopental bolus is frequently given before carotid clamping; however, the concentration achieved and EEG effects are unknown. Our objectives were to administer thiopental prior to carotid clamping and document the time course of (1) the EEG changes; and (2) arterial (A) and venous (V) thiopental concentrations. Since an arterial-venous (A–V) gradient has been shown for other lipophilic drugs, simultaneous A and V samples were analysed to assess whether an A–V gradient exists for thiopental.[3]

Methods

Nine male patients with a mean age of 59.6 years ± 9.2 (S.D.) weighing 86.9 kg ± 13.4 were studied. All patients were ASA physical status 2 or 3 and had stenosis of a carotid artery documented by angiography. Anaesthesia was induced with thiopental (4 $mg \cdot kg^{-1}$) (1st dose) injected over 3 min. Prior to clamping phenylephrine was infused and thiopental (4 $mg \cdot kg^{-1}$) was administered over 3 min (second dose). The average time between the first and second thiopental infusion was 55 min ± 8.5. Simultaneous A and V samples were withdrawn from the radial artery and a central venous line or peripheral vein for analysis of serum thiopental concentration by gas-liquid chromatography using a nitrogen-phosphorus selective detector.

Results

The thiopental concentrations are shown in the table.

TABLE

	First dose (Time (min))						
	0	2	5	10	20	30	con
A $\mu g \cdot ml^{-1}$	0	15 ± 8	10 ± 5	7 ± 3	5 ± 3	5 ± 4	2 ± 1
V $\mu g \cdot ml^{-1}$	0	24 ± 17	15 ± 13	10 ± 6	5 ± 3	5 ± 5	4 ± 2

	Second dose (Time (min))					
	2	5	10	20	30	60
A $\mu g \cdot ml^{-1}$	20 ± 10	13 ± 3	11 ± 5	8 ± 4	6 ± 3	5 ± 3
V $\mu g \cdot ml^{-1}$	21 ± 13	16 ± 9	10 ± 3	10 ± 5	6 ± 2	8 ± 7

All data $\bar{x}$ ± SD, A = arterial, V = venous, con = control.

The EEG was recorded in five patients; in two patients there was transient burst suppression but in all instances

the EEG activity had returned to control by 5 min following the second dose, while the average clamp time was considerably longer (27 ± 4 min).

Discussion

This study shows that (1) EEG changes are transient, disappearing before the removal of the carotid clamp and are associated with thiopental concentrations of 20 $\mu g \cdot ml^{-1}$ or greater; (2) thiopental concentrations fall rapidly with bolus administration, and (3) no sustained A–V gradient is seen. We conclude that either A or V concentrations are sufficient for assessing thiopental therapy; however, an alternative method of administration other than bolus is required to achieve adequate concentrations and EEG changes to afford cerebral protection during carotid endarterectomy.

References

1 *Kassell N, Hitchon PW, Gerk MK et al.* Neurosurgery 1980; 7: 598–603.
2 *Gross CE, Adams HP, Sokoll MD et al.* Neurosurgery 1981; 9: 1–5.
3 *Armstrong PW, Moffat JA, Marks GS.* Circulation 1982; 66: 1273–6.

A randomized double-blind comparison of intramuscular cimetidine and ranitidine

P.W. Harris, D.H. Morison, G.L. Dunn, A.M. Fargas-Babjak, G.C. Moudgil, K. Smedsted, J. Woo
Department of Anaesthesia, McMaster University, Hamilton, Ontario

Ranitidine, a new H_2 blocker, when administered orally or intravenously, has previously been compared with cimetidine, as a prophylaxis against gastric aspiration syndrome.[1] Both drugs were more effective than placebo in raising gastric pH and giving fewer patients "at risk" of pulmonary complications (pH < 2.5) in the event aspiration of gastric contents should occur.[2] Ranitidine produced a higher mean pH than cimetidine and when administered intravenously resulted in fewer patients "at risk." The present study compared the effect of intramuscularly administered cimetidine and ranitidine on gastric pH.

Methods

Institutional approval of the protocol was obtained and all patients gave written, informed consent. One hundred and twenty patients of ASA physical status I and II, 18 to 70 years of age and undergoing elective surgery requiring general anaesthesia with tracheal intubation were studied. Patients were randomly assigned, within blocks of six, to receive either cimetidine 300 mg, ranitidine 50 or 100 mg administered intramuscularly by a nurse not involved with the anaesthetic, at a time anticipated to be one hour prior to induction of anaesthesia. All patients fasted for at least six hours, and narcotic and anticholinergic premedications were not used. After tracheal intubation, a 16 French gauge Salem oro-gastric tube was inserted. The gastric contents were aspirated by an anaesthetist, unaware of the drug used, at intubation and also prior to extubation. The volume of aspirate was recorded and pH measured using a Fisher Accumet 320 pH meter.

Results

The groups were similar with respect to age, weight, and height. The mean time from medication, volume of gastric aspirate, gastric pH and the number of patients "at risk" at the time of intubation are shown in the Table.

TABLE

	n	*Time (min)*	*Volume (ml)*	*pH*	*Number "at risk"*
Cimetidine 300 mg	38	73.8 ±4.5	8.6 ±1.3	5.4 ±0.3	4
Ranitidine 50 mg	37	76.6 ±4.5	7.4 ±1.3	5.6 ±0.2	2
Ranitidine 100 mg	37	79.7 ±4.6	8.9 ±1.0	6.3* ±0.2	1

Values are means ± SEM.
*$p < 0.05$ when compared with cimetidine 300 mg or ranitidine 50 mg. It was not possible to aspirate gastric juice via the Salem tube in eight patients.

Findings at extubation were similar to those at intubation. At extubation the pH following ranitidine 100 mg was significantly higher than cimetidine 300 mg but was similar to ranitidine 50 mg. One patient in each of the cimetidine 300 mg and ranitidine 50 mg groups was considered "at risk" at the time of extubation.

The incidence of drowsiness and/or mild headache as ascertained by a questionnaire prior to induction was low in all three groups. However, 12 patients reported pain at the site of injection following cimetidine 300 mg compared to only two each following ranitidine 50 mg or ranitidine 100 mg ($p = 0.0007$).

Conclusions

Ranitidine 100 mg, when administered intramuscularly approximately one hour preoperatively, would appear to be preferable to either cimetidine 300 mg or ranitidine 50 mg, administered in a similar fashion, with regard to both raising the gastric pH and producing fewer patients "at risk" in the event of aspiration.

References

1 *Morison DH, Dunn GL, Fargas-Babjak AM, Moudgil GC, Smedstad K, Woo J.* A double-blind comparison of cimetidine and ranitidine as prophylaxis against gastric aspiration syndrome. Anesth Analg 1982; 61: 988–92.

2 *Roberts RB, Shirley MA.* Reducing the risk of acid aspiration during Cesarean section. Anesth Analg 1974; 53: 859–68.

A comparative trial of intramuscular cimetidine and ranitidine

J.G. Williams, L. Strunin

Department of Anaesthesia, Foothills Hospital, and University of Calgary, Calgary, Alberta

Aspiration of acid gastric contents may occur during general anaesthesia. H_2 receptor antagonist drugs, such as cimetidine or ranitidine, will decrease gastric volume and increase ph, and may, therefore, reduce the risk of severe acid aspiration syndrome.

Although it has been suggested that intramuscular cimetidine is superior to oral administration, only two trials[1,2] involving a total of 15 patients have been reported using intramuscular cimetidine before anaesthesia. No reported trial has tested intramuscular ranitidine, nor has it been directly compared to intramuscular cimetidine. Ranitidine offers possible advantages over cimetidine in that it has a longer duration of action and does not inhibit hepatic oxidative drug metabolism as does cimetidine.

A controlled trial was carried out on 120 healthy patients coming to elective surgery. The patients were randomly divided into three groups, which received respectively, 100 mg ranitidine, 50 mg ranitidine or 300 mg cimetidine intramuscularly one hour before surgery.

Following induction of anaesthesia, a nasogastric tube was passed, and the stomach contents aspirated, and subsequently analysed for volume and pH. These results were compared with those from a group of 48 untreated control patients from a previous similar study in the same hospital.[3]

Mean gastric juice pH was significantly higher, and mean volume significantly lower in the patients receiving the H_2 receptor blocking drugs than in the control group (Student's t test). Differences in mean pH and volume between the three treated groups were not statistically significant. Thirteen per cent of cimetidine treated patients had a gastric pH of 2.5 or less, compared to 8 per cent of those given 50 mg ranitidine and 3 per cent of those given 100 mg ranitidine. Five per cent of patients given cimetidine had a gastric volume of 25 ml or over and pH less than 2.5, compared to 3.5 per cent of those given 50 or 100 mg of ranitidine. No side effects attributable to the administration of either drug were observed.

We conclude that intramuscular administration of ranitidine or cimetidine is an effective method of reducing the number of patients at risk of acid aspiration during anaesthesia, and that ranitidine appears the preferable drug. However, neither drug eliminates the risk of acid aspiration in all patients, and thus careful anaesthetic technique to protect the airway remains essential.

References

1 *Pickering BG, Palahniuk RJ, Cumming M.* Cimetidine premedication in elective Caesarian Section. Can Anaesth Soc J 1980; 27: 33–5.

2 *Weber L, Hirshman CA.* Cimetidine for prophylaxis of aspiration pneumonitis: Comparison of intramuscular and oral doseage schedules. Anesth Analg 1979; 58: 426–7.

3 *Durrant JM, Strunin L.* Comparative trial of the effect of Ranitidine and Cimetidine in gastric secretion in fasting patients at induction of anaesthesia. Can Anaesth Soc J 1982; 29: 446–51.

Combined pharmacokinetic and pharmacodynamic studies with atracurium besylate (in normal patients and patients with hepatic and renal failure)

S. Ward, D. Wright, I. Corall, E.A.M. Neill

Department of Anaesthesia, Foothills Hospital and University of Calgary, Calgary, Alberta

Atracurium besylate, a new non-depolarizing neuromuscular blocking agent, has been examined pharmacokinetically in both normal patients[1] and in patients with combined renal and hepatic failure.[2] The elimination half life ($T_{\frac{1}{2}}$) of atracurium is similar in both groups with a mean of 21 minutes since the drug is cleared from the body by "Hofmann Elimination", a pH dependent non-enzymatic process. To examine the actions of atracurium at the neuromuscular junction we present further data from these patients.

The two groups of patients were unmatched. In Group I, six patients, ASA class 1, underwent routine minor surgery and were ventilated with O_2, N_2O and halothane (0.5 per cent). Group II consisted of three patients in fulminant hepatic failure (with renal failure), all requiring ventilation for Grade IV hepatic coma. Simultaneous pharmacokinetic and pharmacodynamic measurements were made following a bolus dose of atracurium. Unchanged drug plasma concentrations of atracurium were measured by high pressure liquid chromatography. Single twitch dynamics were examined for force displacement of the adductor pollicis muscle following single supramaximal stimuli to the ulnar nerve at the wrist. For each patient, analysis of plasma decay and

TABLE Mean values ±S.D. for patients given atracurium

	Group I (normals) n = 6	*Group II (hepatic and renal failure) n = 3*
Dose $mg \cdot kg^{-1}$	0.31	0.71
$T_{\frac{1}{2}}$ beta	19.3 ± 2.2	21.5 ± 1.6
EC50 $\mu g \cdot ml^{-1}$	0.29 ± 0.04	0.25 ± 0.05
Hill coefficient	4.6 ± 0.5	3.3 ± 0.6

plasma concentration vs twitch height curves were performed. The mean values from the patients in Group I and Group II are shown in the Table. No statistical comparison can be made as Group I patients were undergoing anaesthesia but it is interesting to note the similarity between the elimination half lives and the EC_{50} (effective concentration giving 50 per cent depression of twitch height).

In conclusion, as in the pharmacokinetic studies, it would appear that the pharmacodynamics of atracurium besylate are unaltered by hepatic or renal failure.

References

1 *Ward S, Neill EAM, Weatherley BC, Corall IM.* Pharmacokinetics of atracurium besylate in healthy patients (after a single I.V. bolus dose). Br J Anaesth 1983 (in press).

2 *Ward S, Neill EAM.* Pharmacokinetics of atracurium besylate in acute hepatic failure (with acute renal failure). Br J Anaesth (in press).

Plasma sulfate conjugated catecholamines during anaesthesia

J. Marty, J. Couture, J. De Champlain

Département d'anesthésie, Hôtel-Dieu de Montréal et Université de Montréal, Montréal, Québec.

Recent reports have examined the effects of anaesthetics on adrenergic responses during surgery.[1,2] Responses were evaluated by measuring variations in concentrations of plasma norepinephrine and epinephrine. However, the methods used in these studies measured only free plasma catecholamines whereas, in man, 70–80 per cent of total plasma catecholamines are sulfate conjugated. Thus, we performed a study in seven ASA physical status I or II patients (age 25–69 years) to delineate variations in sulfate conjugated catecholamines during anaesthesia.

In all cases, induction was achieved with thiopental, 5 $mg \cdot kg^{-1}$, and succinylcholine, 1 $mg \cdot kg^{-1}$, followed by nitrous oxide-halothane for maintenance. Radial artery blood samples were obtained simultaneously before induction of anesthesia (T_1), 1 min after tracheal intubation (T_2) and 1 min after skin incision (T_3) for measurement of total and free norepinephrine (NE) and epinephrine (E) levels using a radio-enzymatic essay method. Sulfate conjugated catecholamines were calculated from these data by subtraction.[3]

As noted in other studies, free NE increased during anaesthesia (table); free E levels decreased. Total NE and E levels decreased significantly while the percentage of sulfate conjugated E increases. Sulfate conjugated catecholamines are usually thought to be of minor importance in the regulation of metabolism and circulation in man.[4] The role they play in anaesthetized patients is currently under study and will be discussed.

TABLE

	T_1	T_2	T_3
Total NE	982	1031	1033
$pg \cdot ml^{-1}$	±174	± 180	± 190
Free NE	185	275*	305*
$pg \cdot ml^{-1}$	± 32	± 48	± 74
NE	79.9	71.2†	69.3†
sulfate conjugated (%)	± 3	± 3.7	± 2.3
Total E	517	441	366
$pg \cdot ml^{-1}$	±188	± 168	± 171
Free E	64	29*	32*
$pg \cdot ml^{-1}$	± 15	± 4	± 6
E	82.4	89.5	89.6
sulfate conjugated (%)	± 4.1	± 2.1	± 2.3

T_1, T_2, T_3 – sampling times – see text.
*$p < 0.05$
†$p < 0.02$.
Values are mean ± SE.

References

1 *Roizen MF, Horrigan RW, Frazer BM.* Anesthetic doses blocking adrenergic (stress) and cardiovascular responses to incision MAC-BAR. Anesthesiology 1981; 54: 390–8.

2 *Pflug AE, Halter JB.* Effects of spinal anesthesia on adrenergic tone and neuro-endocrine responses to surgical stress in man. Anesthesiology 1981; 55: 120–6.

3 *Johnson GA, Baker CA, Smith RT.* Radioenzymatic assay of sulfate conjugates of catecholamines and dopa in plasma. Life Sciences 1980; 26: 1591–8.

4 *Kuchel O, Burr NT, Hamet P et al.* Essential hypertension with low conjugated catecholamines imitates pheochromocytoma. Hypertension 1981; 3: 347–55.

Intrathecal clonidine: analgesia and effect on opiate withdrawal in the rat

B. Milne, F.W. Cervenko, K. Jhamandas
Department of Anaesthesia, Kingston General Hospital & Queen's University, Kingston, Ontario

Systemic clonidine, an alpha agonist, has recently been used to block acute opiate withdrawal.[1,2] Since the adrenergic system is involved in mediating spinal analgesia and problems with intrathecal (IT) opiates include development of tolerance and withdrawal, it was hypothesized that IT clonidine could be substituted for IT opiates in patients with chronic pain. The objective of this study was to assess the effect of IT clonidine on analgesia, arterial blood pressure and morphine withdrawal in the rat.

Methods

Male Sprague-Dawley rats chronically implanted with polyethylene catheters in the lumbar subarachnoid space were used. In analgesia experiments IT clonidine 100–400 nM in 10 μl Ringer's lactate (RL) was administered and analgesia assessed using the tail-flick and hot-plate tests. Analgesia was assessed as the per cent maximal possible effect (%MPE):

$$\left(\%\text{MPE} = \frac{\text{post drug latency-baseline}}{\text{cut off time-baseline}} \times 100\right)$$

In dependency experiments, animals were made dependent using the technique of Frederickson with a single subcutaneous injection of morphine suspension (300 $mg \cdot kg^{-1}$). Seventy-two hours after this injection animals received either IT clonidine 200, 50 or 25 nM in 10 μl RL or IT RL 10 μl. Following intraperitoneal naloxone 3 $mg \cdot kg^{-1}$ withdrawal was assessed by scoring for the presence of typical opiate withdrawal signs. Weight loss and temperature were also recorded and the tail-flick response assessed at appropriate intervals. Intra-arterial blood pressure was recorded following IT clonidine 50 nM.

Results

IT clonidine produced a dose related increase in analgesia.

	[%MPE ± SE (standard error)]			
	100 nM	*200 nM*	*300 nM*	*400 nM*
Tail flick (n = 10)	14.9 ± 6.1	36.9 ± 10.8	57.4 ± 13.4	96.8 ± 9.5
Hot plate (n = 10)	16.5 ± 5.1	54.8 ± 9.0	48.5 ± 12.1	72.7 ± 13.3

IT clonidine had no significant effect on total behavioural withdrawal scores (expressed as per cent) clonidine 25 nM (42.7 per cent, mean, n = 8), 50 nM (39.6 per cent, n = 4) when compared to control (52.1 per cent, n = 16), (analysis of variance $p > 0.5$). IT clonidine did not alter the decrease in tail-flick analgesia produced by naloxone in the dependent rats. Doses of clonidine 200 nM and higher produced hind limb flaccidity and hypothermia in several animals. IT clonidine 50 nM produced a significant decrease in systolic arterial blood pressure from 79 ± 10.2 (SE) mmHg to 61 ± 7.5 mmHg (Student's t-test $p < 0.05$, n = 5).

Discussion

These results suggest that IT clonidine does not modify morphine withdrawal in the rat, and that the effect of systemic clonidine on blocking opiate withdrawal is mediated at higher neural centres. IT clonidine appears to produce analgesia in the rat. However, muscle flaccidity and hypothermia could be potential problems in patients.

References

1 *Deveny P, Mitwalli A, Graham W.* Clonidine therapy for narcotic withdrawal. Can Med Assoc J. 1982; 127: 1009–11.
2 *Gold MS, Pottash AC, Sweeney DR, Kleber HD.* Opiate withdrawal using clonidine. A safe, effective and rapid non-opiate treatment. JAMA 1980; 243: 343–6.

The effects of fentanyl, droperidol and naloxone on an isolated neuron preparation

J.P. Kenefick, S. Roth
Department of Anaesthesia, University of Calgary, Calgary, Alberta

Anaesthesia may be regarded as a drug-induced perturbation of cellular behaviour. Earlier theories of anaesthesia emphasized the importance of lipid solubility and postulated that the mechanism of action of anaesthetics was non-specific. The unitary theory of anaesthesia proposes that a common mechanism of action exists and evidence now suggests that the mechanism of action of anaesthetics at the cellular or membrane level may be dependent on the molecular structure of the agent, thus determining the selectivity of anaesthetic action and the agent's pattern of anaesthesia.[1] Narcotics are often used in large doses as the sole anaesthetic agent: both the analgesic and the anaesthetic effects of opioids are thought to be mediated via the opiate receptor. We therefore examined the effects of high dose fentanyl, alone and in combination with droperidol or naloxone, on the firing of a single neuronal preparation. This preparation, the muscle receptor organ

of the crayfish, has proven to be an excellent model to study the differential effects of anaesthetics.

Method

Stretch receptors from the second abdominal segment of the crayfish (Procambarus clarkii) were isolated together with a length of the dorsal nerve. The single cell, suspended by its muscle fibres, was placed in a tissue chamber containing modified physiological solution. Electrical recordings from the nerve were made with extracellular glass suction electrodes and all signals were amplified and displayed on oscilloscopes. Pre-cooled control or drug containing physiological solution was constantly perfused at 15 $ml \cdot min^{-1}$ and temperature was maintained at 10 ± 1° C. At constant stretch, the firing frequency decayed exponentially to a plateau, basal rhythmical firing, which lasted for several hours. Anaesthetic solutions were applied during this plateau period.

Results

Fentanyl concentrations of 1.0 μM or higher produced an enhancement of firing. The concentration that increased the firing frequency by 50 per cent of control (ED_{50}) was 7.0 μM. During the wash period, the firing rate was depressed below that of control.

The addition of naloxone alone depressed firing in a dose-dependent manner. The concentration that decreased the firing frequency by 50 per cent of control was 4.0 μM. Enhancement of firing occurred during the wash period. Combination experiments with fentanyl and naloxone were performed to test if naloxone could anatagonise the effects of fentanyl. In the presence of a standard concentration of naloxone (1.2 μM, which produced approximately 25 per cent depression), the fentanyl dose-response curve was not significantly altered except at the lower concentration range. Depression of firing was observed during the wash.

Activity was initially increased 76 per cent with droperidol alone up to 13.2 μM, but then decreased 100 per cent. Fentanyl 3.0 μM alone produced 22 per cent enhancement and in the presence of droperidol 5.28 μM increased firing 39 per cent. During the wash period, depression of activity was observed.

Conclusions

These results suggest that the effects of fentanyl on the single neuron are not mediated via the opiate receptor, since the excitatory effects of fentanyl are not antagonised by naloxone. However, the depressant effect of naloxone would appear to augment the excitatory effects of fentanyl in a dose-dependent manner. Thus, opioid anaesthesia, apart from opiate receptor occupancy, may also selectively alter neuronal behaviour in a differential manner. In summary, the action of anaesthetics at the membrane or cellular level may be dependent on molecular structure in addition to the non-specific requirement of lipid solubility.

Reference

1 *Roth SH*. Membrane and cellular actions of anaesthetic agents. Federation Proceedings 1980; 39(5): 1595–9.

Epidural anaesthesia for Caesarean section: Lidocaine-HCl versus lidocaine-CO_2

C.T. Hemmings, S.K. Weeks, J.B. Smith
Department of Anaesthesia, Royal Victoria Hospital and McGill University, Montréal, Québec

It has been suggested that the quality of epidural block for Caesarean section is improved with sacral analgesia.[1] Recently it has been shown that, compared with lidocaine-HCl, L5-S1 block was more complete with lidocaine-CO_2 although there was no difference in the onset times between the two solutions.[2] The present study was designed to compare the spread of analgesia and extent of sacral block with epidural analgesia provided with either lidocaine-CO_2 or lidocaine HCl for Caesarean section.

Methods

Forty patients for elective Caesarean section under epidural anaesthesia were randomly assigned to receive either lidocaine-CO_2 1.86 per cent or lidocaine-HCl 2 per cent, both with 5 $\mu g \cdot ml^{-1}$ of epinephrine. Following prehydration and with the patient in a left lateral tilt and 20° head up position, 12 ml of the test solution were given

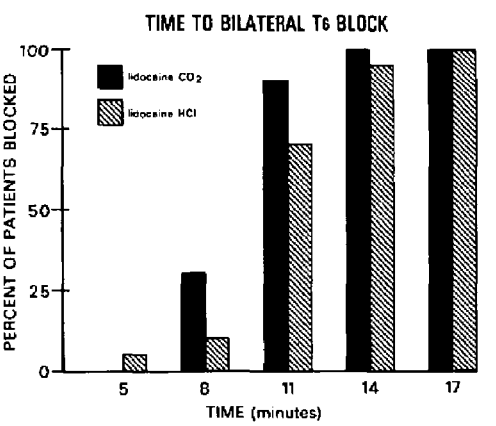


FIGURE 1 Per cent of patients having bilateral T6 block at various time intervals.

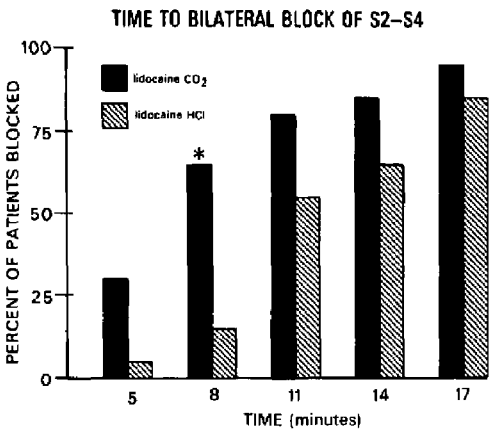


FIGURE 2 Per cent of patients having complete bilateral S2–S4 block at various time intervals. *$p < 0.005$.

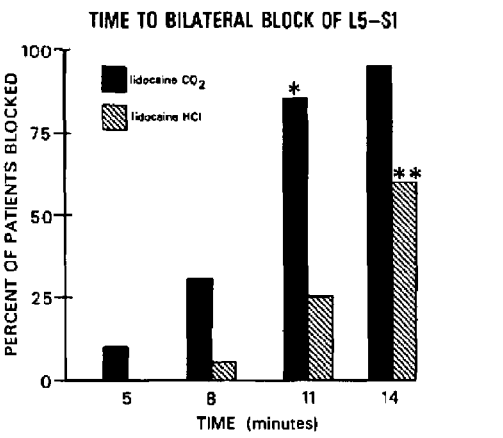


FIGURE 3 Per cent of patients having complete bilateral L5–S1 block at various time intervals. *$p < 0.005$. **$p < 0.025$.

via the epidural catheter. Five minutes later the patient was returned to the horizontal position and a further 8 ml of solution was given. At that time and every three minutes thereafter an observer, unaware of the local anaesthetic used, determined sensory levels by pin prick. Sensory testing was terminated when bilateral T6 block was obtained. The need for intravenous narcotic supplementation was recorded. The speed of onset of bilateral analgesia to T6, L5–S1, S2–4 and the proportion of patients blocked at these levels at various time intervals were compared.

Results

The mean time SEM (min) required to achieve complete block at various levels are shown in the Table (excluding patients who had not achieved bilateral block at the end of testing). The latency of spread to S2–S4 ($p < 0.005$) and L5–S1 ($p < 0.001$), but not to T6 was faster with lidocaine CO_2 (Mann Whitney U-test). A greater proportion of patients in the lidocaine CO_2 group had S2–S4 analgesia at 8 minutes ($p < 0.005$) and L5–S1 analgesia at 11 ($p < 0.005$) and 14 minutes ($p < 0.025$) (CHI^2). There was no significant difference in the need for additional analgesia (CHI^2).

TABLE Mean time (minutes) to bilateral block

	Lidocaine-Co_2	*Lidocaine-HCl*
T6	10.4 ± 0.41 (20/20 patients)	11.6 ± 0.56 (20/20 patients)
S2–S4	8.78 ± 0.88 (19/20 patients)	12.05 ± 0.85 (17/20 patients)
L5–S1	10.05 ± 0.56 (19/20 patients)	12.5 ± 0.58 (12/20 patients)

Conclusions

Lidocaine CO_2, in comparison with lidocaine HCl, is associated with a more rapid and complete block of lumbosacral segments. However, the quality of analgesia for Caesarean section was unrelated to the presence of lumbosacral block. Our results suggest that there is no advantage is using lidocaine CO_2 for Caesarean section. However, when perineal analgesia is rapidly required, as during vaginal delivery, lidocaine CO_2 might be preferable.

References

1 *Thornburn J, Moir DD.* Epidural analgesia for elective Caesarean section. Anaesthesia 1980; 35: 3–6.
2 *Martin R, Lamarche Y, Tetrault L.* Comparison of the clinical effectiveness of lidocaine hydrocarbonate and lidocaine hydrochloride with and without epinephrine in epidural anaesthesia. Can Anaesth Soc J 1981; 28: 217–23.

Foetal responses to acute haemorrhage under halothane anaesthesia

B.Y. Ong, W.A. Tweed, R. Yarnell, D.S. Sitar
Department of Anaesthesia, University of Manitoba, Winnipeg, Manitoba

During the neonatal period, some neonates suffer from acute blood losses. These can occur with accidents to the umbilical cord, placenta previa, abruptio placenta or

Caesarean section incision into the placenta. Many of these neonates are also exposed to anaesthetic agents when emergency Caesarean sections are performed. In the near future, intrauterine foetal surgery may become relatively common. To care for these neonates, we must understand the impact of anaesthetic agents on the ability of the foetus to respond to acute blood loss. Therefore, we investigated the response of foetal lambs to acute haemorrhage under halothane anaesthesia.

Method

Under general anaesthesia, eight ewes of 125 to 135 days gestation were surgically prepared. After recovery for 36 to 48 hours, they were studied under 1.5 per cent halothane–oxygen anaesthesia. Maternal and foetal blood pressures and heart rates were recorded continuously. Maternal and foetal arterial blood gases were obtained at 30-minute intervals and immediately after each blood flow measurement. Foetal organ blood flows were measured with the radioactive labelled microphere technique.

After a steady state of anaesthesia had been established, a complete set of control measurements was made. Foetal arterial blood was withdrawn at 15 $ml \cdot min^{-1}$ until the mean arterial pressure was reduced by 20 per cent. After stabilization for 15 minutes, a complete set of measurements was made. The blood was reinfused and after 15 minutes, the third set of measurements was made.

The ewe and lamb were sacrificed. The foetal organs were weighed and ashed for radionuclide counting. Regional blood flow and total cardiac output were calculated from the counts.

Results

An average of 27.9 ± 7.9 (SD) $ml \cdot kg^{-1}$ of blood was withdrawn to produce a 20 per cent decrease in mean blood pressure. Within two to five minutes, the blood pressure had almost returned to the control value. After acute haemorrhage, the foetal heart rate, total cardiac output, blood flow to the kidneys, the placenta and the musculoskeletal structures were all significantly reduced. Blood flow to the brain, however, increased. With reinfusion of the lost blood, the blood flow reductions were corrected and blood flow to gastrointestinal organs increased significantly.

Conclusion

The foetal lambs were able to tolerate an acute blood loss of 20 per cent of their blood volume under halothane anaesthesia. They compensated for the reduced cardiac output by increasing the systemic vascular resistance and thereby maintain an adequate perfusion pressure and blood flow to critical organs such as the brain. The compensation, however, was incomplete, placental blood flow and hence maternal-foetal exchanges were adversely affected. Halothane anaesthesia impaired the redistribution of cardiac output from the gastrointestinal tract and skin in response to hypovolemia. But halothane did not affect the vasoconstrictions in the carcass and kidneys or the cerebral vessels response to increased carbon dioxide levels.

Anaesthesia and upper respiratory tract infection in the paediatric patient

M.E. McLeod, L. Roy
Department of Anaesthesia, The Hospital for Sick Children, Toronto, Ontario

Children scheduled for minor surgery are often found to have upper airway congestion or have a history of recent URI when examined preoperatively. There is controversy as to whether proceeding with minor surgery is safe.[1,2] This study examined the incidence of perioperative morbidity in patients with a recent or persisting URI.

One hundred and twenty three patients age one month to ten years undergoing minor surgery as outpatients were examined and followed during the perioperative period. The parents of the child were asked to complete a questionnaire one week after surgery to determine whether the child had any health problems in the week following surgery and if so what type of treatment was necessary. Those patients observed to have a mild URI or a recent history of URI were compared to those who were healthy at the time of surgery. Patients with a history of URI and positive physical findings of lung disease were not allowed to proceed to surgery and were excluded from the study.

One hundred and twenty three completed questionnaires revealed that (41/123) 18.7 per cent of the children had a history of upper respiratory infection in the month before surgery. A further (18/123) 14.6 per cent had evidence of on-going disease. There were no significant intra-operative anaesthetic problems; no patient required intubation due to airway difficulties. No patient required admission overnight. Postoperatively, (9/41) 21.9 per cent reported worsening of symptoms and of these 7.4 per cent required medical attention, although none required hospital admission. Of the group without upper respiratory complaints preoperatively, (15/82) 18.3 per cent developed symptoms in the week following surgery.

There is a high (23/123) 33.3 per cent incidence of recent or on-going upper respiratory infection in patients presenting for minor outpatient procedures. The absence of significant intraoperative complications and of medically significant postoperative complications suggests that these procedures can be done safely under general anaesthesia in children with mild coryza.

References

1 *Berry FA*. Pre-existing medical conditions in the paediatric surgical patient. A.S.A. Refresher Course, p. 231, 1981.

2 *McGill WA et al*. Sub-acute respiratory infection in small children. Anesth Analg 1979; 58: 331–3.

Evaluation of a critical appraisal course in anaesthesia

G.L. Dunn, K.J. Bennett

Department of Anaesthesia, McMaster University, Hamilton, Ontario

The ability to appraise critically the published literature is regarded by most teachers of medicine as a desirable skill. However, simple guidelines to facilitate the teaching of these skills have only recently become available. A course in critical appraisal for anaesthetic residents was developed at McMaster, based on the methods of Sackett and colleagues.[1,2] The objectives of this study were to evaluate the effectiveness of the course in teaching these skills to residents, and to determine whether it should be included in the core curriculum in Anaesthesia.

Methods

Eight residents in the McMaster Anaesthesia Residency Programme were given a course in critical appraisal of papers dealing with (a) therapy (effectiveness) and (b) causation/prognosis. This comprised reading materials, and selected papers together with four seminars each of 1½ hours' duration, held at monthly intervals. Following the four seminars, each resident was required to select a topic based on the course, perform a mini-literature search, and make a ten-minute presentation on this subject, thereby demonstrating the critical appraisal skills which he/she acquired in the previous sessions.

Prior to, and following completion of the course, all residents completed a pre- and post-test which contained one short paper on therapy, prognosis and causation. These tests were assessed by an individual who was not involved in the teaching sessions, using a standardised scoring system. In addition, all residents were asked to evaluate the course and to make suggestions for improvement.

Results

Both pre- and post-tests were completed by eight residents. Mean pre-test scores were 0.5 and 0.88 for the causation and therapy units respectively. Mean post-test scores were 1.62 and 3.12. Analysis by the Wilcoxon signed rank test indicated a statistically significant improvement for the therapy unit ($p < 0.05$) but not for the causation unit.

All residents evaluated the course highly and recommended that it be continued. The commonest suggestion for improvement was that the seminars be spaced at weekly rather than monthly intervals.

Discussion

The low pre-test scores indicate that none of the residents in the group were familiar with the concepts presented. The lack of change in the causation post-test may be due to the relatively long time interval between seminars and the fact that this unit was presented first. The significant, although small, improvement occurring after the therapy unit is encouraging. A modified course will be presented in the future and will be assessed in a similar manner.

References

1 *Trout KS*. How to read clinical journals: IV. To determine etiology or causation. Can Med Assoc J 1981; 124: 985–90.

2 *Sackett DL*. How to read clinical journals: V. To distinguish useful from useless or even harmful therapy. Can Med Assoc J 1981; 124: 1156–62.