EFFECT OF PASSIVE HYPERVENTILATION ON SEIZURE DURATION IN PATIENTS UNDERGOING ELECTROCONVULSIVE THERAPY

S. N. CHATER AND K. H. SIMPSON

Electroconvulsive therapy (ECT) is used widely by psychiatrists in the U.K., and there is good evidence of its efficacy in the treatment of depression [1, 2]. Modification of ECT by brief general anaesthesia and partial neuromuscular paralysis has reduced the morbidity associated with the procedure [3]. A bilateral grand mal convulsion must be induced for a therapeutic response to be seen after ECT [4, 5]. When unilateral electrode placement is used it is still necessary to induce a bilateral seizure [5]. A minimum seizure duration may be needed for effective treatment and a single seizure requirement of at least 25–30 s has been suggested [4, 6]. Cumulative seizure durations of 50–400 s using conventional ECT [7] and 210–1000 s during a course of multiple monitored ECT [8] have been proposed. However, the existence of a direct relationship between the efficacy of ECT and seizure duration has been questioned [9,10]. Seizure duration during ECT is dependent on many factors, including concurrent drug therapy [11] and the type and dose of anaesthetic induction agent used [10]. Seizure duration is not dependent on electrode placement, type of stimulating current or electrical energy applied, as long as a supramaximal stimulus is delivered [12]. It was suggested that paralysis and hyperventilation with oxygen resulted in the prolongation of seizure activity [13]. However, it has since been shown that, as long as hypoxaemia is prevented, seizures are not augmented by increasing inspired oxygen concentration alone [14]. Active hyperventilation during the recording of an electroencephalogram enhances epileptiform activity; therefore, hypocapnia may influence seizure activity [15]. In support of this concept, increased seizure duration was seen in association with a decrease in end-expired carbon dioxide concentration ($E'_{CO_2}$), by full paralysis, intubation and hyperventilation of patients having ECT [14]. The present study was designed to evaluate three different modes of ventilation before the application of an ECT stimulus.

PATIENTS AND METHODS

Thirty patients with major depressive illness (DSM-III criteria [16]) were included in the
study which was approved by the Hospital Ethical Committee. Patients gave informed verbal consent, and no patient receiving ECT under the provision of the Mental Health Act was involved. Each patient was undergoing a course of bilateral ECT and was studied during three consecutive treatments over a period of 10–14 days. Patients having the first treatment of a course of ECT were not included, as it is known that the duration of seizures is prolonged at this time [5, 17]. Concurrent medication was not altered during the study.

Eight male and 22 female unpremedicated patients aged 31–91 yr, and weighing 30–100 kg, were studied. Before the induction of anaesthesia an earlobe oximeter probe (Ohmeda Biox 3700) was positioned to measure transcutaneous oxyhaemoglobin saturation (Sao2) throughout the treatment. Patients were asked to breathe 100% oxygen from an anaesthetic facemask, until Sao2 98% was achieved. Anaesthesia was induced with methohexitone 1 mg kg

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and this was followed by suxamethonium 0.5 mg kg

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. The doses of induction agent and neuromuscular blocker remained constant for each patient during the three ECT treatments studied. On each occasion the patients received a different mode of ventilation after induction of anaesthesia and before the application of the ECT electrodes. They received, in randomized order, no further ventilation, or 10 or 20 breaths of hyperventilation with 100% oxygen using a facemask and an oropharyngeal airway. A Mapleson A attachment, modified by replacement of the expiratory valve by an Ambu E valve [18], was used with a fresh gas flow of at least 200 ml kg

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. ECO2 was sampled through the facemask and measured using a capnograph (Datex Normocap), which was calibrated with a standard gas mixture before and after each session. A pen recorder was used to obtain a record of the ECO2 immediately before the application of the ECT stimulus, and after the termination of the seizure. Patients did not receive further ventilation between the two recordings of ECO2. The ECT stimulus was from the same Ectron Dupulse machine, the output of which was tested before each treatment session. Bifrontotemporal electrodes were applied in a standard position by the psychiatrist, after thorough degreasing of the skin. A bilateral 3-s constant current (850 mA), unidirectional 50-Hz sine wave was used, which delivered 33 J. Seizure duration was timed by observation of the isolated forearm as described by Fink and Johnson [6].

The results were analysed using linear regression and analysis of variance for correlated means, followed by the Tukey test, where appropriate.

RESULTS

Sao2 did not decrease to less than 90% in any patient, at any time, during anaesthesia or the seizure. Ten or 20 breaths before the application of the ECT stimulus significantly reduced mean ECO2 compared with no ventilation (/ = 40.73, P < 0.01) (table I). Mean ECO2 was significantly greater after the seizure when the patients received no ventilation before the shock compared with those occasions when they received 10 breaths (/ = 5.68, P < 0.05) or 20 breaths (/ = 5.68, P < 0.01) (table I). Mean seizure duration was significantly increased when the patients received 20 breaths, compared with those occasions on which they received 10 breaths or no further ventilation (/ = 11.57, P < 0.01) (table I). There was sig-

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<th>ECO2 before seizure (%)</th>
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<td>(4.75–5.15)</td>
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<td>ECO2 after seizure (%)</td>
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<td>5.80*</td>
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<td>Seizure duration (s)</td>
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<td>(25.8–34.5)</td>
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<td>30.3</td>
<td>32.4</td>
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significant between-subjects variation in seizure duration ($f = 10.90, P < 0.01$).

Analysis of variance of the change in seizure duration (duration after 20 breaths minus duration after no further ventilation) did not reveal significant between-subjects variation ($f = 2.77, \text{ns}$). There was no significant correlation between $\epsilon'_{\text{co}_2}$ before the seizure and the seizure duration. There was no significant correlation between the change in $\epsilon'_{\text{co}_2}$ during the seizure and seizure duration.

DISCUSSION

Twenty breaths of passive hyperventilation with 100 % oxygen, using a facemask and non-rebreathing system, reduced $\epsilon'_{\text{co}_2}$ and prolonged seizure duration in patients undergoing ECT. The anaesthetic technique was simple and could be used routinely. Bergsholm, Gran and Bleie [14] described an anaesthetic technique involving prolonged neuromuscular blockade and tracheal intubation; however, this could not be incorporated readily to clinical practice in the U.K.

Concurrent medication was not altered and patients acted as their own controls during the present study, to limit the effects of drug treatment on seizure duration. Hypoxaemia may occur during routine ECT treatment [19], and may play a role in limiting seizure duration [20]. Measurement of $S_{\text{ao}_2}$ in the present study excluded hypoxaemia as a factor affecting seizure duration. Preoxygenation to achieve $S_{\text{ao}_2}$, 98 % ensured that hypoxaemia did not occur during treatment, even when patients received no further ventilation. Preoxygenation could, therefore, be used to prevent hypoxaemia in patients in whom it is deemed necessary to avoid passive ventilation, but monitoring of oxygen saturation is still desirable.

Considerable variation in seizure duration between individuals has been documented previously [8] and was apparent in the present study. The lack of correlation between $\epsilon'_{\text{co}_2}$ before a seizure and seizure duration may be explained by individual variation in seizure duration. The lack of between-subjects variation in change in seizure duration, after 0 or 20 breaths, suggests that the effect of hyperventilation on seizure duration was consistent. The increase in $\epsilon'_{\text{co}_2}$ seen during the seizure did not correlate with its duration, perhaps because carbon dioxide production is dependent on muscle activity as well as the duration of apnoea. Although the duration of each seizure was measured, it was not possible to grade the intensity accurately.

In conclusion, passive hyperventilation using 20 breaths of 100 % oxygen significantly prolonged seizure duration in patients undergoing ECT, and could easily be incorporated to current clinical practice.

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REFERENCES