Patients with sleep apnoea hypopnoea syndrome (SAHS) have been shown to be at a significantly greater risk of having a traffic accident than the general population. As driving is an essential part of everyday life for most people, physicians treating patients with SAHS have come under increasing pressure to assess their driving ability. Furthermore, there is little evidence to help advise patients when driving can be safely restarted after institution of treatment or whether it is safe to continue driving if treatment is missed for a few nights—for example, when away on business or a short holiday. Assessing an individual’s ability to drive is difficult and prediction from physiological and clinical markers of SAHS is poor. Simple computer-based driving simulators which measure the ability to track and maintain attention—two key components of driving—have recently been developed. Patients with SAHS have been found to perform poorly on such simulators, comparable to the effect of driving with a blood alcohol concentration above the legal limit.

Improvements in driving simulator performance have been reported following several months of treatment with continuous positive airways pressure (CPAP) in patients with SAHS. However, it is not known how quickly these improvements are achieved and lost. The aim of this study was to assess the time course of changes in driving simulator performance in patients with SAHS following treatment with continuous positive airways pressure (CPAP).

Methods: Eighteen patients with severe SAHS performed a driving simulator test at baseline (before treatment) and at days 1, 3, and 7 of a 2 week CPAP trial period. CPAP was then discontinued and the patients performed three further driving simulator tests after 1, 3, and 7 days. Eighteen patients with severe SAHS acted as controls and performed the driving simulator test on seven occasions in a pattern similar to that of the treated patients.

Results: Significant improvements in tracking error (p = 0.004), reaction time (p = 0.036), and the number of off road events per hour (p = 0.032) were seen in the CPAP treated group compared with the controls at 7 days. Following discontinuation of CPAP for 7 days a significant difference in driving simulator performance persisted between the two groups, but the size of the difference had reduced.

Conclusion: Driving simulator performance in patients with severe SAHS improves within the first few days of starting CPAP and these improvements appear to be sustained for up to 1 week after withdrawal. Further data about the usefulness of driving simulators in predicting safe driving are needed before these results can be used in advising patients on driving. However, the data appear to suggest that driving can be safely resumed after a few days of effective CPAP treatment.

METHODS

Subjects
Eighteen patients with moderate to severe SAHS who agreed to participate were recruited to the study when they attended for a 2 week trial of CPAP treatment. Each patient had undergone an in-hospital automatic CPAP titration study (Autoset Clinical 1, ResMed (UK), Abingdon, Oxon) and had been listed for a 2 week CPAP trial. Patients try CPAP for 2 weeks at home and then return it before being reviewed in clinic a few weeks later, when a decision about long term treatment is made; this is routine practice in our laboratory. Eighteen patients recruited from the Sleep Clinic with moderate to severe SAHS (respiratory disturbance index (RDI) >50 events per hour and Epworth score >12) who had also been listed for CPAP acted as controls and performed the driving simulator tests before any CPAP trial. A brief clinical history and examination was obtained on each patient and the Epworth score was recorded.

Written consent was obtained before participation and the study protocol was approved by the local ethics committee.

DRIVING SIMULATION

Each patient performed a 20 minute divided attention driving simulation test (DADS) after a 5 minute practice
session using a commercially available simulator (SimDrive Divided Attention Driving Simulator, Stowood Scientific Instruments, Oxford, UK) at baseline (before CPAP). The object of the test was to steer an image of a car bonnet down the centre of a winding road as accurately as possible (measuring ability to track) using a standard computer game steering wheel (Grandprix 1, Thrustmaster, USA). The test automatically stopped if the car was off the road for more than 15 seconds. During the test single digits, which changed randomly, were displayed at the corner of the screen. To test vigilance and reaction time the subjects were required to identify the number “2” when it appeared by pressing a button on the same side of the steering wheel as it appeared on the screen.

The 18 patients who underwent the CPAP trial performed three more 20 minute tests on days 1, 3, and 7 on CPAP. After 2 weeks CPAP was discontinued and the subjects performed three further tests on days 1, 3, and 7 off CPAP. The 18 subjects who acted as controls also performed six further simulator tests in a pattern identical to the CPAP treated patients. All driving simulation tests were performed at the same time of day (18.00 hours was chosen because this was the time that patients attended for their CPAP loan and hence was the time of their first baseline study). All subjects were asked to refrain from drinking coffee for 6 hours and alcohol for 24 hours prior to the tests. Results were expressed as tracking error (standard deviation from the centre of the road), reaction time (average time to respond to target number), and number of off road events per hour.

Sleep study and CPAP trial
Limited sleep studies were carried out using either the Autoset Clinical 1 (ResMed (UK), Abingdon, Oxon) or the Densa DMS2000 (Ferraris Medical Ltd, Enfield, UK). The Densa DMS2000 records oronasal airflow (thermistors), oxygen saturation, snoring (microphone), thoracic and abdominal respiratory effort (strain gauges), and heart rate (ECG). The Autoset Clinical 1 detects apnoeas, hypopnoeas, and inspiratory flow limitation through a flow sensor attached to the patient with nasal cannulee. The results were interpreted using standard criteria with the RDI on CPAP (events/h) 11.1 (10) N/A N/A 0.285 (NS)

Epworth score

| Age (years) | 49.9 (10) |
| Sex (% male)† | 94% |
| BMI (kg/m²) | 39 (7.7) |
| Neck circumference (cm) | 47.3 (3.9) |
| RDI (events/h) | 59.8 (16.9) |
| RDI on CPAP (events/h) | 11.1 (10) |
| Epworth score* | 15.5 (12.75–19) |

CPAP treated group Controls p value

DISCUSSION
This study shows that driving simulator performance in patients with SAHS improves quickly after starting treatment with CPAP; vigilance, tracking, and the ability to keep the “car” on the road all improved during the first 7 days of starting CPAP. Following discontinuation of CPAP, driving simulator performance appeared to be relatively well preserved but was beginning to fall off by day 7. There are a number of limitations to this study. Firstly, as with all repeated tests of skill, there was the possibility of a “learning effect” on the driving simulator. However, all
patients underwent a 5 minute practice session at baseline to accustom them to the use of the simulator. One study has suggested that at least three 5 minute practice runs are required to abolish any learning effect on a similar simulator, but a further study found no significant learning effect after 5 minutes on a simulator slightly different from the one used in this study (subjects were asked to keep a cross in a box rather than to steer along a road). The fact that our control patients, who were not treated with CPAP but performed the simulator test at similar intervals as the treated patients, did not demonstrate any significant changes in their ability suggests that any learning effect was minimal. Secondly, our study population was a selected population of patients with severe SAHS and marked hypersonnolenence and therefore these observations cannot be generalised to all patients attending a sleep clinic who, on average, will have milder disease.

Limited sleep studies using either the Densa DMS2000 or the Autoset Clinical 1 were used to establish the diagnosis of obstructive sleep apnoea (OSA) and assess its severity (RDI). Studies have shown the sensitivity and specificity of the Densa DMS2000 to be 82% and 90% for the diagnosis of OSA and of the Autoset to be 100% and 92%; however, both machines underscored hypopnoeas when compared with full polysomnography. We may therefore have underestimated the severity of OSA in terms of RDI in this study. Furthermore, a recent meta-analysis of diagnostic tools in obstructive sleep apnoea (OSA) and assess its severity (RDI). The results of this study compare favourably with a previous study by Lamphere et al which showed that objective sleepiness improved in SAHS patients after just one night of treatment with CPAP. The improvement continued over time but appeared to plateau at 14 nights; the authors argued that this implied that patients with SAHS suffer from a chronic functional sleep loss from which it takes several nights of CPAP to recover. In our study, although significant improvements in driving simulator performance were seen after one night of CPAP, the improvements appeared to continue until day 7. A further study by Kribbs et al showed that CPAP improved both subjective and objective sleepiness and psychomotor vigilance after 30–237 days in 15 patients with SAHS. However, all of these improvements were lost if the CPAP was withdrawn for just one night. Our study did not demonstrate such a rapid return of sleepiness, although we did not measure objective sleepiness with multiple sleep latency tests and poor psychomotor performance. We did see a return of subjective sleepiness but this took 7 days to become statistically significant; this difference may be explained in part by the small numbers of patients in each study. There was a trend toward deterioration in psychomotor performance in our study which did not reach statistical significance by day 7; however, our patients were using a divided attention driving simulator test (DADS) compared with the psychomotor vigilance test (PVT) used in the study by Kribbs et al.

A number of studies have shown a reduction in car accidents in patients with SAHS successfully treated with CPAP. Findley et al showed that SAHS patients using CPAP regularly had a lower rate of car accidents than those not using CPAP (p<0.02). Krieger et al in a study of 547 SAHS patients, found that the average number of accidents (p<0.01) and near miss collisions (p<0.01) was reduced following treatment with CPAP. George showed that, after 3 years of treatment with CPAP, the rate of car accidents fell significantly in 210 SAHS patients compared with the 3 years before the CPAP was instituted. Furthermore, the accident rate remained high over the time period in 27 patients with SAHS who were unable to tolerate CPAP, a pattern of results similar to the driving simulator performance data in our study.

Others have also shown improvements in simulator performance following treatment of SAHS. Hack et al demonstrated improvements after 1 month of CPAP compared with placebo treated controls, and Haraldsson et al found improvements using a complex simulator following treatment with UVPPP. The magnitude of changes was similar to those found in our study. It is not certain, however, how performance on a simple driving simulator reflects “on
road” driving ability. The fact that driving simulator performance improves and the number of adverse driving events is reduced after treatment of SAHS does not mean that the two are linked and that data derived from the driving simulator can be relied upon in making judgements about a patient’s ability to drive. However, there is emerging evidence to suggest a link between driving simulator ability and risk of a car crash. Findley et al have presented work, as yet only published in abstract form,22 showing that SAHS patients with a history of a car crash had a higher rate of poor performance on a driving simulator than those without a prior crash. We have also shown in a further study of 120 patients that the number of off road events per hour on a driving simulator has an independent association with a previous car crash.23

Further studies are needed but, if simulator data are shown to be useful predictors of on road driving ability, then our data show that improvement is seen rapidly after starting treatment and is not lost even after a few days without treatment. Once patients are established on treatment, driving can probably be safely resumed after a few days.

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