Fitness to Drive After Intravenous Sedation and General Anaesthesia: A Literature Review

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Introduction

Current recommendations by the Australian and New Zealand College of Anaesthetists are that after undergoing general anaesthesia or intravenous sedation, a patient should not drive a car until the following day.[1] In the United Kingdom patients are advised not to drive for 24 hours. In this age of modern day case anaesthesia is this based on sound evidence or are we maintaining the status quo? To date there has not been a systematic review or meta-analysis of this topic, i.e. level I evidence as defined by the National Health and Medical Research Council.[2] In this paper the available evidence is examined. The anaesthetic agents discussed are those most commonly used in current day case anaesthesia. Fitness to drive is assessed by psychomotor function tests, multiple sleep latency tests, and simulated driving tests. Recovery after undergoing sedation or anaesthesia, is also compared with functioning at the legally safe blood alcohol levels (BALs) for driving as recommended by the World Health Organisation.[3]

Clinical Trials

Investigators have been studying the effects of general anaesthesia on driving ability for decades. In 1972, Ogg found that 73% of car owners drove within 24 hours after undergoing a general anaesthetic, and 9% actually drove home![4] Recently the percentage of patients driving after an anaesthetic has fallen, however Correa et al found that 4% of patients still drove within 24 hours, despite advice not to.[5] Most agree that patients should never drive immediately after anaesthesia but for what period remains debatable. In the 1970s Havard wrote: "With most general anaesthetics, it is safer to advise against driving for 48 hours afterwards."[6] This was based on the finding that tissue concentrations of anaesthetics and/or their metabolites are evident for 48 hours.

Articles used for this literature review were initially found by a search of the National Library of Medicine. Key words used were: general anaesthesia, driving, midazolam, diazepam, propofol, fentanyl, alfentanil, nitrous oxide, desflurane, sevoflurane, and isoflurane. References from studies found by the above means were then used to find further studies. Trials were excluded if: they involved anaesthetic agents not commonly

in current use or not available in Australia; aimed at studying short term recovery and recovery room behaviour only; studying recovery after operations involving overnight hospital stays (except reference 19); not written in English. The trials reviewed and listed in the tables are all randomised controlled trials or equivalent, i.e. level II evidence.[2]

Relationship between Anaesthetic Agents, Driving skills, Psychomotor Tests, and Multiple Sleep Latency Tests

Driving is a complex task. It involves attention, information processing, judgement, sensorimotor skills, and perception.[7] All these functions are affected by the anaesthetic agents used in day case anaesthesia. Research has attempted to evaluate these anaesthetic effects in the hope of gaining sufficient evidence to confidently identify a prudent non driving period.

The clinical trials quoted in this review utilised testing of a variety of psychomotor skills, multiple sleep latency time periods, and driving skills. Brief descriptions of individual psychomotor tests are available in the Appendix. Practice (or learning) effect, whereby results improve with repeated testing, is mentioned where applicable to a study. The tables indicate if training has been used to minimise this effect.

Psychomotor studies (upon which most of this review is based) generally define "recovery time" as the time taken for the mean test results of the experimental group to return to baseline or control levels. Unfortunately this methodology could fail to identify an individual subject who is much slower to recover than the rest of the group. For safety in real life we would prefer to know the recovery time the very slowest person could take. In addition there is conflicting evidence on the sensitivity of the different psychomotor tests. Tracking tasks, the peg board test, the maddox wing test, and perceptive accuracy tests appear to be the most sensitive psychomotor tests. Choice reaction tests, critical flicker fusion threshold, and free recall appear to be the most controversial. The recovery of free recall was inconsistent with other tests in most papers and has therefore been ignored in the summaries made in this review. Marshall et al (1992) found that control subjects also had impaired free recall with subsequent testing.[8]

Multiple sleep latency tests are an alternative but valuable method of assessing if a person is fit to drive. Sleep latency is measured as the time taken to reach the first epoch of non-wakefulness.[9] Improved driving performance has been shown to be associated with increased sleep latency times.[10] Lichtor et al (2002) found these tests to be more sensitive than psychomotor tests.[11]

Actual car driving ability is the gold standard in assessing fitness to drive after an anaesthetic. This is especially true when ability is compared with subjects at the legal BAL for driving. However, actual driving is often not a practical option. Driving simulators can be used instead. The main features recorded from the simulators are brake reaction times and performance errors (neglected instructions, driving off the road, and collisions).[12]

The ultimate test of fitness to drive, the motor vehicle accident mortality and morbidity figures from recently anaesthetised patients driving, cannot of course be studied. Interestingly, a review of motor accidents in Tasmania over the past 15 years has shown no deaths have occurred which could be attributed to either general anaesthesia or sedation. (Personal communication, Kathryn Campbell, Government Analyst.) No information was available on motor accidents not resulting in death.

The electroencephalogram (EEG) was also performed in one study.[13] The relationship between EEG abnormalities and driving ability has not yet been determined.

Midazolam and Diazepam Trials

Many trials have studied recovery after midazolam and diazepam used for sedation. These are listed in Table 1.

In summary, the effects of both midazolam and diazepam on psychomotor tests and car driving ability are essentially gone by 10 hours.

Propofol Trials

Propofol is a commonly used both as an anaesthetic and a sedation agent. Details of relevant research on propofol are given in Table 2.

To summarise, the effects of propofol on psychomotor function appear to be largely dissipated by 2 hours post anaesthetic. At a blood propofol concentration of 0.2 mcg/ml psychomotor impairment is equivalent to a BAL of 20 mg/100 ml.

Fentanyl and Alfentanil Trials

Few clinical trials have studied the recovery of psychomotor function and driving ability post fentanyl or alfentanil when administered alone. Details of the available trials are summarised in Table 3.

In the very limited studies performed, recovery (apart from EEG changes) after a single dose of fentanyl or alfentanil appears to occur by 6 hours. The recovery time of fentanyl is effected by the dose administered.

Inhalational Anaesthetic Trials

Details of the available trials of inhalational agents are given in Table 4.

It can be seen that testing of the volatile agents in isolation in regard to post-anaesthetic fitness to drive is limited. Studies conducted have been relatively small and time-limited. Objective recovery after N_20 appears to be consistently less than 30 minutes, but subjective recovery has been reported as being prolonged for up to 8 hours. Recovery occurs after desflurane in 3 hours. Sevoflurane recovery has not been adequately studied. However, with its pharmacokinetic profile, it could be assumed to lie somewhere between the 2-3 hour recovery period for desflurane and the 5-7 hour recovery period for enflurane and halothane.

Combined Anaesthetic Agent Trials

In practice most sedative and anaesthetic regimens utilise a combination of agents. Table 5 summarises these studies.

Trials studying a combination of midazolam, fentanyl, and propofol in sedative doses have found a recovery time of within 8 hours. Studies using propofol as the maintenance agent have revealed a recovery time of 1 hour. Trials utilising propofol and N_20 as the maintenance agents have shown a recovery time of 3 hours or less. Studies using a desflurane/N_20 anaesthetic have found a recovery time of within 3 hours. Trials studying recovery after an isoflurane/N_20 maintenance anaesthetic have usually found a recovery time of 1.5 hours or less. One exception is the Marshall et al trial in which recovery only approached baseline by 3 hours.[8] In the same study, another group who had received an alfentanil infusion added to this anaesthetic did not achieve baseline levels by 5 hours. Trials studying recovery after a sevoflurane/N_20 maintenance combination anaesthetic are lacking. Only one study met this reviews criteria, hence, no comment can be made on recovery time.

Interestingly, recovery from a balanced anaesthetic using a combination of agents

Table 1
Summary of recovery after midazolam and diazepam

Anaesthetic agent	Number subjects	Procedure	Tests used	Psychomotor recovery time period	Comments	Reference
Midazolam 15 mg (oral)	7	None	2 psychomotor tests & car driving ability.	10 hours	Practice effect evident. Looked at recovery the next morning. No testing between 1 & 10 hours.	(14)
Midazolam 0.05/ 0.1/0.15 mg/kg	11	None	8 psychomotor tests	7 hours	Minimal practice effect	(15)
Midazolam 5/10 15/20 mg (oral)	7	None	2 psychomotor tests	7 hours	Minimal practice effect	(16)
Midazolam 0.1 mg/kg	16	None	6 psychomotor tests	3 hours (except maddox wing and subjective fatigue)	Minimal practice effect	(17)
Midazolam 0.05 mg/kg	25	Bronchoscopy	3 psychomotor tests, Romberg's test & ability to walk in a straight line.	2 hours undertaken.	No training	(18)
Midazolam 0.1 mg/kg	24	Bronchoscopy	"	>2 hours (significant impairment of ability to walk in a straight line)	No further testing after 2 hours.	(18)
Midazolam 0.075 mg/kg (mean) (+ spinal block)	13	TURP	8 psychomotor tests	2 hours — 3/9 tests remained impaired. 24 hours — free recall only - impaired	No testing between 2 & 24 hours. No training. Included because of comparison with propofol (see later section)	(19)
Diazepam 10/20 mg	10	None	8 psychomotor tests & EEG monitoring	6 hours (EEG changes & memory recall >8 hours)	Minimal practice effect	(13)
Diazepam 0.15/ 0.3 mg/kg	11	None	8 psychomotor tests	7 hours	Minimal practice effect	(15)
Diazepam 0.2 mg/kg	27	Bronchoscopy	3 psychomotor tests, Romberg's test, and ability to walk in a straight line.	2 hours	Practice effect evident	(18)
Diazepam 0.3 mg/kg	11	None	5 psychomotor tests	8 hours	Practice effect evident	(20)

Note: Recovery times are based on the time taken for the mean test result to return to baseline or control levels.

Table 2
Summary of recovery after propofol

Anaesthetic agent	Number subjects	Procedure undertaken	Tests used	Psychomotor recovery time period or alternative measure	Comments	Reference
Propofol 0.54 mg/kg + 5/4/3 mg/kg/hr Mean anaesthetic duration 40 minutes	13	TURP	8 psychomotor tests	1 hour — except free recall (normal by 24 hours)	This study compared propofol with midazolam (see earlier comments) Propofol offers a more rapid recovery.	(19)
Propofol (TCI) 0.8/0.4/0.2 mcg/ml	10	None	3 psychomotor tests	0.2 mcg/ml equivalent to BAL 20 mg/ 100 ml (0.02%) although compared with baseline	Good study design in that functioning at a set propofol concentration was compared with functioning at a set BAL. Training undertaken.	(21)
Propofol Plasma concentration 3.9±1.0 mcg/ml (mean±SD) Anaesthetic duration 1 hour	7	None	Subjective sleepiness, fatigue, and sleep latency	Subjective tests normalized within 1 hour 20 minutes		(22)
Propofol 4.4 mg/kg	18	Minor gynaeco-logical	6 psychomotor tests	2 hours	Training undertaken however practice effect evident.	(23)

Note: Recovery times are based on the time taken for the mean test result to return to baseline or control levels.
TCI=target controlled infusion

appears to be no longer than that using an individual agent. In fact it is usually shorter. This is probably a result of lower individual drug doses being used.

Discussion

In setting guidelines as to when a person is fit to drive after sedation or anaesthesia many factors need to be taken into account. Most studies test fitness to drive using psychomotor tests, simulated driving tests, or multiple sleep latency tests. Although only an indirect way of assessing the risk to the patient and the public they can be performed scientifically and have been validated against the medical and legal benchmark of BALs. Lack of impairment on one particular test may not of course equate to being fit to drive a motor vehicle. A whole battery of tests need to be investigated and practice effects need to be taken into account. The practice effect noted in approximately half the studies may bias the results towards a shorter recovery. Considerable inter-individual variation in psychomotor testing after anaesthetics has also been found.

Most of the studies were been done on fit, healthy volunteers who did not undergo any operative procedure. Patients were excluded from the studies if they were taking other medications. Many studies have also excluded subjects with organ dysfunction and/or other illnesses, for example obstructive sleep apnoea. Obstructive sleep apnoea alone may

Table 3
Summary of recovery after fentanyl and alfentanil

Anaesthetic agent	Number subjects	Procedure undertaken	Tests used	Psychomotor recovery time period	Comments	Reference
Fentanyl						
a) 100 mcg	10	None	8 psychomotor tests & EEG monitoring	2 hours	Minimal practice effect.	(13)
b) 200 mcg	"	"	"	6 hours EEG effects seen for up to 8 hours (Increase in frontal fast activity)	Highlights the dose dependent effect of fentanyl on recovery.	(13)
Fentanyl 2.5 mcg/kg	7	None	2 psychomotor tests	2 hours	Minimal practice effect	(24)
Fentanyl 100 mcg	9	None	1 psychomotor test only — tracometer	>2 hours	Testing only undertaken for 2 hours. Practice effect evident.	(25)
Fentanyl 167 mcg + Etomidate 20 mg + maintenance doses	22	Cystoscopy	2 psychomotor tests	>1 hour	No training undertaken.	(26)
Alfentanil 500 mcg + Etomidate 20 mg + Maintenance doses	25	Cystoscopy	"	1 hour	No training undertaken — practice effect evident.	(26)

Note: Recovery times are based on the time taken for the mean test result to return to baseline or control levels.

affect one's ability to drive, via increased fatigue[10], and if combined with an anesthetic these patients might have prolonged effects.

In addition, anxiety experienced by the patients prior to procedures and its effect on sleep deprivation and increased sedation/anaesthetic requirements has not been evaluated objectively in any study. The effect of post-operative pain on driving ability has not been evaluated either.

As driving is an individual action which may inadvertently affect others we need to take into account the time needed for the slowest patients to recover from the anaesthetic. It is not safe to give a time when the "average" patient has recovered. It must be the time when all patients are fit to drive. Most time periods mentioned in this review are unfortunately only "mean" times. Documenting of the range of times of recovery from anaesthetics may be a more appropriate method. There is some variation between studies and we need to weight decisions on "evidence" from those with the most conservative rate of recovery.

Conversely, it also needs to be accepted that to drive a car, total recovery after sedation or anaesthesia need not occur. Recovery of function only needs to be equivalent to that with a BAL of 50 mg/100 ml.

Table 4
Summary of recovery after inhalational agents

Inhalational agent	Number subjects	Procedure undertaken	Tests used	Psychomotor recovery time period or alternative measure	Comments	Reference
$N_20/0_2$ 50/50	12	Colonoscopy	4 psychomotor tests	No post-procedural impairment.	Practice effect evident on one test despite training. Testing undertaken as soon as patient able to walk into testing area (within 30 minutes).	(27)
N20/02 50:50	80	Flexible Sigmoid - oscopy	1 psychomotor test only — adaptive tracking task.	No post-procedural impairment. Better than at a BAL of 80 mg/ 100 ml.	Compared function-ing with that at a BAL of 80 mg/100 ml & with controls.	(28)
$N_20/0_2$ 30:70 Anaesthetic duration 40 minutes	11	None	4 psychomotor tests	22 minutes	Compared with the above 2 studies impairment was seen. Training undertaken.	(29)
N20/02 Up to 50:50	5	None	5 psychomotor tests	20 minutes Except free recall.	Subjects felt subjectively unwell for up to 8 hours. Training undertaken.	(30)
Desflurane ET 8.3% (mean) Mean anaesthetic duration 53 minutes	16	Elective day case surgery	2 psychomotor tests	2 hours	Training under-taken. Subjects received only local anaesthetics or oral ibuprofen for analgesia.	(31)
Desflurane ET 7.4% (mean) Anaesthetic duration 1 hour	20	None	9 psychomotor tests	3 hours	Training undertaken	(32)
Sevoflurane Fi 1-2% + $N_2O/0_2$ 67:33 Mean anaesthetic duration 17.6 minutes	34	Colonoscopy	9 psychomotor tests	30 minutes except free recall impaired for >120 minutes	Testing only undertaken for 2 hours. Training occurred.	(33)
Halothane/ $N_20/0_2$ Induced at high conc, then reduced to Fi 0.7% for 3.5 minutes	11	None	4 psychomotor tests & simulated driving test.	>5 hours (psycho-motor testing); driving ability recovered by 7 hours.	Psychomotor testing only under-taken for 5 hours. Study included as a comparison with the newer agents.	(12)
Enflurane/ $N_20/0_2$ Induced at high conc, then reduced to Fi 1.5% for 3.5 minutes	11	None	"	>5 hours (psycho-motor testing) although driving ability recovered by 4.5 hours.	"	(12)

Note: Recovery times are based on the time taken for the mean test result to return to baseline or control levels. ET=end-tidal. Fi=fraction inspired.

Table 5
Summary of recovery after combined anaesthetics

Anaesthetic agents	Number subjects	Procedure undertaken	Tests Used	Psychomotor recovery time period or alternative measure	Comments	Reference
a) Propofol 2.5 mg/kg	12	None	5 psychomotor tests & multiple sleep latency test.	4 hours including sleep latency period.	Sleep latency period is more sensitive than psychomotor testing. Combinations including propofol but excluding midazolam decreased sleep latency the least.	(11)
b) Propofol 2 mg/kg + Fentanyl 2 mcg/kg	"	"	"	"	"	(11)
c) Propofol 2 mg/kg + Midazolam 2 mg/70 kg	"	"	"	4 hours 6 hours until recovery of sleep latency period. Range: up to 8 hours.	"	(11)
d) Midazolam 0.07 mg/kg + Fentanyl 2 mcg/kg	"	"	"	"	"	(11)
Fentanyl 1 mcg/kg + Midazolam 0.05 mg/kg + 0.025 mg/kg PRN + Propofol 10-20 mg PRN	35	Colonoscopy	9 psychomotor tests	2 hours except free recall	Training undertaken Testing occurred for for only 2 hours.	(33)
a) Fentanyl 50 mcg/70 kg + Propofol 35 mg/70 kg	12	None	4 psychomotor tests	30 minutes until = BAL 100 mg/100 ml	To be more relevant to the Australian population a BAL of 50 mg/100 ml would be more appropriate. Relatively low drug doses used.	(34)
b) Fentanyl 50 mcg/70 kg + Midazolam 2 mg/70 kg	"	"	"	60 minutes until = BAL 100 mg/100 ml		(34)
c) Fentanyl 50 mcg/70 kg + Midazolam 2 mg/70 kg + Propofol 35 mg/70 kg	"	"	"	75 minutes until = BAL 100 mg/100 ml		(34)
Midazolam 0.1 mg/kg + Fentanyl 2 mcg/kg	12	None	8 psychomotor tests	3 hours Approaching baseline.	Training undertaken.	(35)
a) Propofol Induction 203.7 mg (mean) + 12/8 mg/kg/hr + Alfentanil 500 mcg + 250 mcg 15 minutely (operation time 15-79 minutes)	15	Knee Arthroscopy	2 psychomotor tests	1 hour	Practice effect evident with choice reaction time though not with the perceptive accuracy test.	(36)
b) Propofol Induction 212 mg (mean) + Fi Isoflurane 0.5-2% + Alfentanil 500 mcg + 250 mcg 15 minutely (operation time 18-73 minutes)	"	"	"	1 hour	"	(36)
Propofol 10/8/6 mg/kg/hr +/- Alfentanil 10 mcg/kg Mean anaesthetic duration 13 minutes.	46	Oesophago-scopy & Bronchoscopy	1 psychomotor test only - Critical flicker fusion threshold.	1 hour	Minimal practice effect	(37)

Table 5
Continued

Anaesthetic agents	Number subjects	Procedure undertaken	Tests Used	Psychomotor recovery time period or alternative measure	Comments	Reference
a) Propofol 2.5 mg/kg + 10 mg PRN+ N_2O/O_2 66:34 Mean anaesthetic duration 9.7 minutes	30	Outpatient gynaecological	2 psychomotor tests	1 hour	Compared their study subjects with controls hence practice effect not an issue.	(38)
b) Propofol 2.5 mg/kg N_2O/O_2 66:34 + Fi Isoflurane 1% Mean anaesthetic duration 12.9 minutes	"	"	"	1 hour	"	(38)
a) Propofol 2 mg/kg + 10 mg/kg/hr+ N_2O/O_2 67:33 Mean anaesthetic duration 51.4 minutes	20	Knee Arthroscopy	2 psychomotor tests	1.5 hours	Did not take the practice effect which occurred into account.	(39)
b) Propofol 2 mg/kg+ N_2O/O_2 67:37+ Fi Isoflurane 0.9% Mean anaesthetic duration 49.9 minutes	"	"	"	1.5 hours	"	(39)
a) Propofol 2.5 mg/kg + Propofol 9/6 mg/kg/hr + N_2O/O_2 67:33 Mean anaesthetic Duration 33.5 minutes	32	Dental surgery	4 psychomotor tests	3 hours (Return to baseline levels only except for free recall.)	Matched with a control group who achieved consistently better results than baseline at 3 hours (practice effect) except with free recall.	(8)
b) Propofol 2.5 mg/kg + Propofol 9/6 mg/kg/hr + N_2O/O_2 67:33 + Alfentanil 10 mcg/kg/hr Mean anaesthetic duration 34.5 minutes	25	Gynaecological laparoscopy	"	5 hours (Just approaching baseline)	8% of subjects unable to even take the tests. Tissue stores must have been saturated with alfentanil to account for this prolonged sedation.	(8)
c) Propofol 2.5 mg/kg + Fi Isoflurane 1% + N_2O/O_2 67:33 Mean anesthetic time 32.3 minutes	32	Dental surgery	"	3 hours (Return to baseline levels only.)	See above comments for (a)	(8)
d) Propofol 2.5 mg/kg + Fi Isoflurane 1% + N_2O/O_2 67:33 + Alfentanil 10 mcg/kg +10 mcg/kg/hr Mean anaesthetic duration 40.2 minutes	25	Gynaecological laparoscopy	"	5 hours (Just approaching baseline)	2% unable to take tests.	(8)
a) Propofol 230 mg (mean) + 10/6 mg/kg/hr + N_2O/O_2 67:33 + Alfentanil 920 mcg (mean) Mean anaesthetic duration 33 minutes	24	Knee Arthroscopy	2 psychomotor tests	>1 hour	This group received a higher dose of alfentanil compared with the group below. No testing occurred after 1 hour. Large inter-individual variation seen.	(40)

Table 5
Continued

Anaesthetic agents	Number subjects	Procedure undertaken	Tests Used	Psychomotor recovery time period or alternative measure	Comments	Reference
b) Propofol 237 mg (mean)+ Fi Isoflurane 0.5-2% + N_2O/O_2 67:33 + Alfentanil 740 mcg (mean) Mean anaesthetic duration 24 minutes	26	"	"	<1 hour		(40)
Propofol 2.5 mg/kg + Desflurane 1.25 MAC + N_2O/O_2 60:40 Anaesthetic duration 1 hour	20	None	9 psychomotor tests	3 hours	Training undertaken	(32)
Propofol 2.5 mg/kg + Fentanyl 1mcg/kg + N_2O/O_2 50:50 + Desflurane 1 MAC for 30 minutes	4	None	Simulated driving	3 hours At this time simulated driving was comparable with a BAL 50 mg/ 100ml.	Good study design. Compared functioning with that at the legal BAL for driving. Unfortunately only used small numbers. No training undertaken.	(41)
a) ET desflurane 4.7% Mean anaesthetic duration 146 minutes	16	Elective limb orthopaedic surgery	2 psychomotor tests	1 hour	No training undertaken Possible practice effect.	(42)
b) ET Isoflurane 0.8% Mean anaesthetic duration 149 minutes Both groups were combined with: Midazolam 1-2 mg + Fentanyl 50 mcg+ Thiopentone 7 mg/kg + N_2O/O_2 60:40	9	"	"	1 hour	"	(42)
Propofol 2-3 mg/kg + Fi Isoflurane 0.5-2% + Alfentanil 980 mcg (mean) Mean anaesthetic duration 39.5 minutes	15	Knee Arthroscopy	4 psychomotor tests	1 hour	Practice effect seen with 3 of the 4 tests. Not seen with the perceptive accuracy test.	(43)
Sevoflurane ET Sevo 0.23% + Fentanyl 1.5 mcg/kg + N_2O/O_2 66:34 Mean anaesthetic duration 57 minutes	13	Non - neurological elective surgery	2 psychomotor tests & visual evoked potentials	1 hour except visual evoked potentials > 90 minutes	No further testing after 90 minutes. Practice effect evident but not accounted for.	(44)

Note: Recovery times are based on the time taken for the mean test result to return to baseline or control levels unless otherwise specified.
MAC = minimal alveolar concentration
ET = end tidal
Fi = fraction inspired

Table 6 gives a summary of the longest recovery times for all agents. Even acknowledging the cautionary points in previous paragraphs the evidence in this review has shown remarkably rapid psychomotor recovery with the modern anaesthetic agents. The studies to date have shown that midazolam, fentanyl, and propofol anaesthetics appear to be associated with virtually total recovery within 10 hours. Some studies have shown the occasional psychomotor test, for example free recall, to remain impaired for up to 24 hours but whether this test is very discriminatory or even has a significant effect on driving skills is debatable. EEG changes have also been shown to persist for >8 hours but the significance of this for driving has not been determined. When compared with legal driving limits for alcohol, these anaesthetics compare very favourably, skills being the same as at a 50 mg/100 ml alcohol level within 3 hours. Nitrous oxide has been shown to have a very rapid objective recovery period when used as a single agent, but in one study was associated with a significant subjective feeling of being "unwell" for up to 8 hours. The implications of this for driving are difficult to ascertain. Is it like driving when we have a cold or flu? The anaesthetics conducted with volatile agents are not as clear cut. Studies involving desflurane show rapid recovery times of within 3 hours. However, evidence on sevoflurane is insufficient to make conclusions, and evidence on isoflurane is only available from combination anaesthetics. Most of the combination or balanced general anaesthetic techniques have shown a recovery within 8 hours.

It appears that if a patient needs to be as alert as possible postoperatively the best anaesthetic agents to use for sedation are propofol or N_20, with or without fentanyl (in doses <100 mcg). For general anaesthetics the best maintenance agents are propofol with

Table 6
Summary of longest recovery times of all agents (from 2 or more level II evidence trials)

Anaesthetic agent	Longest psychomotor recovery time period or alternative measure	Number of studies
Midazolam (Maximum dose 0.15 mg/kg)	10 hours	6 (14, 15, 16, 17, 18, 19)
Diazepam (Maximum dose 0.3 mg/kg)	7 hours	4 (13, 15, 18, 20)
Propofol	2 hours	4 (19, 21, 22, 23)
Fentanyl (Maximum dose 2.5 mcg/kg)	6 hours	4 (13, 24, 25, 26)
$N_20/0_2$ (Maximum concentration 50:50)	0.5 hours	4 (27, 28, 29, 30)
Desflurane	3 hours	2 (31, 32)
Propofol/midazolam/fentanyl/ alfentanil	8 hours	6 (11, 33, 34, 35, 36, 37)
Propofol/N_20 maintenance (+ alfentanil infusion >5 hours (8))	3 hours	4 (8, 38, 39, 40)
Desflurane/N_20 maintenance (±midazolam/fentanyl/propofol/ thiopentone)	3 hours	3 (32, 41, 42)
Isoflurane/N_20 maintenance (±midazolam/fentanyl/alfentanil boluses/propofol/thiopentone) (+ alfentanil infusion >5 hours (8))	3 hours	7 (8, 36, 38, 39, 40, 42, 43)

or without N_20, desflurane/N_20, or isoflurane/N_20. If analgesia is required after a procedure it would seem logical to use non-sedative drugs such as paracetamol, non-steroidal antiinflammatory agents or local anaesthetics.

Conclusion

After conducting this review one could conclude that after a minimum period of 12 hours following day case sedation or anaesthesia it is probably safe to drive a motor vehicle. The caveat being that this time may have to be extended for individuals in poorer health, taking other medications, or having larger total doses of agents than quoted here. In addition, as a patient who drives 12 hours after a procedure is almost certainly driving at night, night driving ability then becomes important. In practice it would be appropriate to advise patients that it would be safe to drive the next morning. As with all medical decisions requiring justification with scientific evidence there is room for further large controlled trials. A multi-centre study involving a real-life cross section of patients having actual day surgical procedures, and looking specifically at their functioning after 12 hours, would be ideal.

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Appendix

Description of Psychomotor Tests

Psychomotor Test	Description
Choice reaction time	Time required to react to one specific stimulus, with a distinct response, when presented with multiple stimuli.
Critical flicker fusion	Requires the subject to discriminate flickering in a set of "four light emitting threshold diodes in foveal fixation at one metre."
Free recall	Ability to recall 9 objects off a picture card 15 minutes later.
Maddox wing test	Measures the divergence of the eyes (extraocular muscle balance) and is representative of general muscle tone.
Peg board test	Subject puts tight-fitting pegs through holes as quickly as possible.
Perceptive accuracy test	Involves reacting to a 2 digit number flashed transiently up on a screen by pressing the same numbers on a keyboard.
Tracking task	Subject maintains a marker icon in contact with a target circle moving across the screen.
Tracometer	A steering task.
Visual Evoked Potentials	Measurement of the integrity of the visual neural pathway.