ELSEVIER

Ambulatory Surgery 4 (1996) 19–23

Ambulatory Surgery

Recovery after day surgery with intravenous anaesthetic agents

Paul H. Carroll*, T.W. Ogg

Day Surgery Unit, Addenbrooke's NHS TrustCambridge, CB2 2QQUK

Accepted 5 May 1996

1. Introduction

In 1847 John Snow in his work *On the Inhalation of the Vapour of Ether* recognised that elderly patients recovered more slowly than younger patients. He also documented that post-operative nausea and vomiting (PONV) and respiratory depression were important recovery complications. In addition he also noted a period during recovery when the 'mind wanders'. A century ago mortality was the major concern following general anaesthesia whilst anaesthetists in day surgery units now expect a good quality, swift recovery with pain well controlled and a low incidence of PONV. The aim of this article will be to define what recovery really is and to determine the methods used to assess it. Only then will it be pertinent to examine which intravenous anaesthetic agent either for induction or maintenance, will produce the best possible recovery profile. The qualities of the ideal intravenous anaesthetic agent are outlined in Table 1.

Table 1
Properties of an ideal intravenous anaesthetic agent

1.	Rapid onset (requires high lipid solubility and un-ionised at blood pH to allow penetration of blood-brain barrier)
2.	Rapid recovery (rapid redistribution and metabolism with no accumulation)
3.	Analgesia at sub anaesthetic concentrations
4.	Minimal cardiovascular and respiratory depression
5.	No emetic effects
6.	No excitatory phenomena (e.g. coughing, hiccough, involuntary movements) on induction
7.	No emergence phenomena (e.g. nightmares)
8.	No epileptiform activity
9.	No interaction with neuromuscular blocking drugs
10.	No pain on injection, venous sequelae and safe if injected inadvertently into an artery
11.	No toxic effects on other organs with no stimulation of porphyria
12.	No hypersensitivity reactions or release of histamine
13.	Water-soluble formulation with long shelf-life

2. The definition and importance of recovery

2.1. Recovery phases

Recovery may be conveniently divided into three phases and all anaesthetists should appreciate these phases as many relevant publications discussing recovery refer to these time intervals.

Phase 1 Immediate recovery may be defined as the return of consciousness and protective reflexes following general anaesthesia.

Phase 2 Intermediate recovery lasts for up to 2–3 h and most day units will continue to nurse these patients within their wards. There is a need for patients to return to street fitness before being discharged from day units.

Phase 3 Late or full recovery defines the phase when all the effects of general anaesthesia have disappeared. Usually this relates to a 24-h period after anaesthesia.

The importance of a early recovery lies in the achievement of airway control and protection although a shorter stay in the recovery room may have important cost saving implications, i.e. the longer the recovery the more nursing time has to be resourced. The intermediate period of recovery on the ward has been thoroughly investigated to determine differences between anaesthetic agents and at this time complications such as PONV may occur. Both PONV or a delayed return to street fitness on the ward account for approximately 20% of hospital admissions from a dedicated day unit

* Corresponding author. Day Surgery Unit, Addenbrooke's NHS Trust, Cambridge, CB2 2QQ, UK.

PII S0966-6532(96)00107-2

Table 2
Common recovery tests in anaesthetic practice

1. Clinical Tests	(a) Orientation
	(b) Sitting unaided
	(c) Walking in a straight line
	(d) Romberg's test
	(e) Picking up matches
	(f) Countdown test
	(g) Memory function
2. Paper and pencil tests	(a) Deletion of 'P's
	(b) Triegers' test
3. Psychomotor tests	(a) Maddox wing test
	(b) Flicker fusion test
	(c) Pegboard test
	(d) Post box test
	(e) Reaction timing
	(f) Simulated driving
	(g) EEG recordings
	(h) Critical flicker fusion test

[1]. These admissions will have obvious cost implications and may even defeat the cost effectiveness of day surgery. Furthermore a rapid and good quality late phase of recovery will be important to reduce the loss of earnings for day patients. Perhaps of even greater importance is the reduction of the risk of motor vehicle accidents, home accidents and the avoidance of costly litigation.

2.2. Quantitative measurement of recovery

Recovery may be assessed in three ways and examples of common recovery tests are outlined in Table 2.

A major problem when comparing the recovery characteristics of agents is that to determine any differences between anaesthetic agents becomes more difficult with time, thus more complex tests may be required to show these recovery variations. Problems of patient boredom and loss of compliance will then appear with more complex and accurate tests. No single test has been identified which provides reliable recovery information for all aspects of psychomotor functions following general anaesthesia.

Table 3
Discharge criteria — Addenbrooke's Day Surgery Unit 1995

1.	Stable vital signs
2.	Alert and oriented
3.	Tolerating oral fluids
4.	Able to sit unaided
5.	Pain controlled, wound checked
6.	Written and verbal discharge instructions
7.	Medication to take home and mobility aids provided
8.	Responsible adult escort with patient

Table 4
Approximate elimination half-lives of the agents

Agent	Half-life (h)
Thiopentone	11.5
Propofol	3–4.8
Methohexitone	4
Etomidate	1.25

The criteria for patient discharge from the Addenbrooke's day surgery unit are outlined in Table 3. Although this duty may be delegated to the nursing staff the responsibility still lies with the anaesthetist involved with these day cases.

3. Agents influencing recovery

It is now appropriate to consider the various intravenous agents used in day surgery which may influence recovery. This consists of two sections, the first being the effect of different induction agents on recovery and secondly the differences between maintenance with intravenous agents compared with themselves and also their volatile inhalation anaesthetic counterparts. Additional factors which may potentially delay day case recovery times include sedative premedication and prophylactic pre-emptive analgesic regimes.

3.1. Intravenous induction agents

Propofol is the most popular day case anaesthetic induction agent although thiopentone, methohexitone and etomidate do have their advocates. So far there have been few studies comparing recovery of these agents with ketamine in a day case setting. Table 4 shows the half-lives of these agents. It may be tempting to draw Firm conclusions about their recovery performance from this table but much of their activity is related to redistribution and not metabolism thus making meaningful comparison difficult.

Indeed propofol has been compared to other induction agents for short procedures and there is evidence which records no alteration in post-operative co-ordination [2]. One study has reported that discharge time was independent of which ever induction agent was used, including thiopentone [3]. However evidence shows that psychomotor impairment exists for up to 5 h with thiopentone as compared to 1 h following propofol [4,5]. Again there have been claims of a significant difference in sitting up and street fitness times together with a reduced incidence of PONV in a propofol group [6]. Propofol compares favourably with methohexitone producing a faster recovery of psychomotor performance although again after 4 h there was

no difference recorded between thiopentone, methohexitone or propofol [7]. Other work has noted that propofol patients have a better sense of well-being compared to other intravenous agents but whether this is attributable directly to the agent itself or to lack of PONV or barbiturate 'hangover' remains unclear [8].

When propofol was compared to thiopentone in children it was found that in children less than 5 years old only the time to spontaneous eye opening was shorter after propofol. However in children aged 5–11 years old, times for spontaneous eye opening, giving name and discharge were shorter after propofol induction. These results indicate that propofol hastened early recovery in children undergoing day case surgery, but earlier discharge occurred only in older children [9].

3.2. Intravenous anaesthetic agents for maintenance

On examination of recovery following intravenous agents when used for of anaesthesia or sedation several studies have looked at these agents in comparison with each other but perhaps the most interesting debate arises when the recovery aspects of intravenous anaesthetic agents are compared with their volatile counterparts. During sedation when propofol, methohexitone and midazolam were compared it was discovered that the vigilance and concentration of the subjects were worse in the midazolam and methohexitone groups [10]. There is also evidence that premedication with midazolam prior to sedation with propofol may even increase anxiolysis and sedation without affecting discharge from the recovery room [11]. Indeed the use of midazolam premedication prior to general anaesthesia does not appear to alter the patients ability to reach street fitness times in the day surgery context [12].

When propofol and thiopentone were compared as maintenance agents for brief surgical procedures the recovery in memory and psychomotor performance was notably superior in the propofol group. The subjective feelings of tiredness, drowsiness and alertness were all worse in the thiopentone group even at 24 h [13]. This is not surprising given the different pharmacology of the agents and the potential for accumulation with thiopentone.

Again methohexitone and etomidate have been studied, together with althesin, in the short surgery setting and it was found that recovery from methohexitone appeared the fastest. It was interesting to note that in this study it was found to be too difficult to produce good operating conditions with etomidate alone and the etomidate group recorded the highest complication rate [14].

When propofol and methohexitone were compared in outpatient anaesthesia propofol was associated with fewer side effects e.g. hiccough, PONV and the phase 1 and 2 recovery times for awakening and ambulation were shorter in the propofol group [15].

The common theme throughout these studies comparing the intravenous agents against themselves for maintenance in day case surgery is not the question of recovery. It would appears that propofol has a superior recovery profile as shown by psychomotor testing but often discharge times are similar. Perhaps of greater importance is that the quality of recovery appears better in the propofol groups and the incidence of peri-operative side-effects and complications is lower when propofol is used. Therefore, quality day case anaesthesia is probably more important than recovery.

3.3. Recovery aspects of total intravenous anaesthesia (TWA) compared to volatile anaesthetic maintenance

TIVA has become popular in many day surgery units and the use of propofol for maintenance should be compared with the older and newer generation of volatile inhalational anaesthetic agents. When propofol TIVA was compared to an anaesthetic comprising thiopentone or halothane induction together with halothane maintenance m children, the TIVA group was the slowest to recover with no difference in recovery even if thiopentone was used for induction instead of halothane [16]. Again TIVA recovery has been compared with an enflurane anaesthetic and the immediate recovery was shorter in the propofol group. There would appear to be an increase in well-being again recorded in the TIVA groups but the time to reach discharge criteria was the same in both groups in one study [17], but significantly shorter in the propofol group in another publication [18]. Finally, both studies showed there was an increased incidence of PONV in the enflurane group.

When propofol TIVA was compared with isoflurane maintenance conflicting results arose showing minor differences in psychomotor test results but overall propofol provided a faster recovery [19–22]. Again a higher incidence of PONV was noted in the isoflurane groups. If isoflurane was used to supplement TIVA immediate recovery was slowed and the incidence of PONV was higher although discharge times remained the same [23]. If propofol is used to finish major cases using isoflurane immediate recovery was faster but the incidence of PONV was still higher than TIVA alone [24]. In a direct comparison between TIVA and isoflurane in major cases extubation times were longer in the TIVA groups but recovery appeared to be similar [25].

The newer agent sevoflurane may offer smooth inhalational induction characteristics with a 30% faster immediate recovery compared to propofol. However the incidence of PONV was high but in the intermediate phase of recovery awareness, confusion and co-ordination were similar [26]. Desflurane is known to produce a high incidence of airway complications if

used for an inhalational induction but it may offer rapid recovery even after long surgery and minimal metabolism. Desflurane recovery was again faster than propofol in the early phase of recovery but by 2 h psychomotor test times were equal. Although the street fitness times were similar the desflurane group recorded a 50% incidence of PONV against the 12% of the propofol patients [27–30].

Finally one group investigated TIVA alone and recorded the reasons for prolonged first phase recovery. A total of 14 882 patients was studied and prolonged awakening, defined as greater than 15 min from the end of general anaesthesia, occurred in 6.8% of cases. The mean wake up time was 7.2 min and the factors associated with this were males, endotracheal intubation, age > 65, abdominal surgery, infusion > bolus, addition of isoflurane and a total dose of propofol > 8 mg/kg [31].

4. Conclusions

Total intravenous anaesthesia (TIVA) with propofol and alfentanil or fentanyl has its advocates for day case anaesthesia in Britain. At the Addenbrooke's demonstration day unit approximately 35% of anaesthetics are TIVA [32] but newer volatile agents have now entered the market with rapid recovery profiles.

Recovery will depend on your definition and care should be taken to describe which phase of recovery is being tested and by which recovery tests. The duration and type of surgery will influence anaesthetic recovery as will the expertise of the anaesthetist with whatever agent is used.

As regards the intravenous agents in day surgery it is the quality of recovery which is important in addition to the incidence of peri-operative complications. Etomidate produces PONV and is difficult to use intra-operatively with methohexitone having a high incidence of airway complications. Thiopentone gives similar discharge times to propofol but hangover effects still remain. Therefore, for induction it would appear that propofol has a good recovery profile and the suppression of laryngeal reflexes assists the introduction of the Brain laryngeal mask airway.

Which agent should be used for the maintenance of anaesthesia? The debate is still open and although desflurane produces the most consistent early recovery there is little evidence to support large significant variations in the speed to street fitness with any particular technique. Indeed there is a remarkable similarity with many recovery tests at 60–120 min following the cessation of general anaesthesia. However, there is little doubt that PONV is associated with volatile anaesthesia and so in this respect propofol TIVA will always produce a rapid good quality recovery.

Recent evidence in the costing of day case anaesthesia has proven that propofol was indeed more expensive than volatile agents [33]. However, this finding will have to be offset by the expense of day case hospital admission especially with moderate to severe PONV after volatile anaesthesia. Basically there is no single anaesthetic agent which will produce the overwhelmingly best recovery profile and for day surgery the individual anaesthetist should make his or her own choice. However the authors believe that even the most recently introduced inhalational agents will find it hard to compete with TIVA in the form of propofol and alfentanil for day case surgery.

5. Additional references

Aitkenhead AR. Intravenous anaesthetic agents. In: Aitkenhead AR,Smith G, eds. Textbook of Anaesthesia. London: ChurchillLivingston, 1990.Cooper G. Recovery from Anaesthesia. Anaesthesia Rounds 1986; No. 19.

References

[1] Ogg TW, Carroll PH, Penn S. Addenbrooke's NHS Trust Day Surgery. Workload Report 1983–1995.

[2] Ryom C, Flarup M, Suadican P, Palm T, Mikkelsen S, Gyntelberg F. Recovery following thiopentone or propofol anaesthesia assessed by computerised coordination measurements. *Acta Anaesthesiol Scand* 1992; **36** (6): 540–545.

[3] Heath PJ, Kennedy DJ, Ogg TW, Dunling C, Gilks WR. Which intravenous induction agent for day surgery? A comparison of propofol, thiopentone, methohexitone and etomidate. *Anaesthesia* 1988; **43** (5): 365–368.

[4] Kortilla K, Nuotto EJ, Lichter JL, Ostman PL, Apfelbaum J, Rupani G. Clinical recovery and psychomotor function after brief anaesthesia with propofol or thiopentone. *Anaesthesiology* 1992; **76** (5): 676–681.

[5] Gupta A, Larsen LE, Sjoberg F, Lindh ML, Lennmarken C. Thiopentone or propofol for induction of isoflurane based anaesthesia for ambulatory surgery? *Acta Anaesthesiol Scand* 1992; **36** (7): 670–674.

[6] Chittleborough MC, Osborne GA, Rudkin GE, Vickers D, Leppard PI, Barlow J. Double-blind comparison of patient recovery after induction with propofol or thiopentone for day case relaxant general anaesthesia. *Anaesth Intens Care* 1992; **20** (2): 169–173.

[7] Reader JC, Misvaer G. Comparison of propofol induction with thiopentone or methohexitone in short out patient general anaesthesia. *Acta Anaesthesiol Scand* 1988; **32** (8): 607–613.

[8] McDonald NJ, Mannion D, Lee P, O'Toole DP, O'Boyle C, Keane PK. Mood evaluation and out-patient anaesthesia. A comparison between propofol and thiopentone. *Anesthesia* 1988; **43** Suppl: 68–69.

[9] Runcie CJ, Mackenzie SJ, Arthur DS. Comparison of recovery from anaesthesia induced in children with either propofol or thiopentone. *Br J Anaesth* 1993; **70** (2): 192–195.

[10] Atanassoff PG, Alon E, Pasch T. Recovery after propofol, midazolam and methohexitone as an adjunct to epidural anaesthesia for lower abdominal surgery. *Eur J Anaesth* 1993; **10** (4): 313–318.

[11] Taylor E, Ghouri AF, White PF. Midazolam in combination with propofol for sedation during local anaesthesia. *J Clin Anaesth* 1992; **4** (3): 213–216.

[12] Turner GA, Peach M. A comparison of oral midazolam solution with temazepam as day case premedicants. *Anaesth Intens Care* 1991; **19** (3): 365–368.

[13] Heath PJ, Ogg TW, Gilks WR. Recovery after day case anaesthesia. A 24 h comparison of recovery after thiopentone or propofol anaesthesia. *Anaesthesia* 1990; **45** (11): 911–915.

[14] Craig J, Cooper GM, Sear JW. Recovery from day case anaesthesia. A comparison between methohexitone, althesin and etomidate. *Br J Anaesth* 1982; **54** (4): 447–451.

[15] Doze VA, Westphal LM, White PF. Comparison of propofol with methohexitone for out-patient anaesthesia. *Anaesth Analg* 1986; **65** (11): 1189–1195.

[16] Aun CS, Short TG, O'Meara ME, Leung DH, Rowbottom YM, Oh TE. Recovery after propofol infusion anaesthesia in children; a comparison with propofol, thiopentone or halothane induction followed by halothane maintenance. *Br J Anaesth* 1994; **72** (5): 554–558.

[17] Ding Y, Fredman B, White PF. Recovery following outpatient anaesthesia; use of enflurane versus propofol. *J Clin Anaesth* 1993; **5** (6): 447–450.

[18] Millar JM, Jewkes CF. Recovery and morbidity after day case anaesthesia. A comparison of propofol with thiopentone-enflurane with and without alfentanil. *Anaesthesiology* 1988; **43** (9): 738–743.

[19] Larsen LE, Gupta A, Ledin T, Doolan M, Linder P, Lennmarken C. Psychomotor recovery following propofol or isoflurane anaesthesia for day care surgery. *Acta Anaesthesiol Scand* 1992; **36** (3): 276–282.

[20] Nightingale JJ, Lewis IH. Recovery from day case anaesthesia; comparison of total i.v. anaesthesia using propofol with an inhalational technique. *Br J Anaesth* 1992; **68** (4): 356–359.

[21] Kortilla K, Ostman P, Faure E et al. Randomised comparison of recovery after propofol-nitrous oxide versus thiopentone-isoflurane-nitrous oxide anaesthesia in patients undergoing ambulatory surgery. *Acta Anaesthesiol Scand* 1990; **34** (5): 400–403.

[22] Doze VA, Shafer A, White PF. Propofol-nitrous oxide versus thiopentone-isoflurane-nitrous oxide for general anaesthesia. *Anaesthesiology* 1988; **69** (1): 63–71.

[23] White PF, Stanley TH, Apfelbaum JL et al. Effects on recovery when isoflurane is used to supplement propofol-nirous oxide anaesthesia. *Anaes Analg* 1993; **77** (4 Suppl): 515–520.

[24] Chang Y, Lin SY, Susetio L, Hu JW, Liu CC. Propofol modifies recovery from isoflurane-nitrous oxide anaesthesia. *Acta Anaesthesiol Sin* 1994; **32** (2): 89–94.

[25] Kalman SH, Jensen AG, Ekberg K, Eintrei C. Early and late recovery after major abdominal surgery. A comparison between propofol anaesthesia with and without nitrous oxide and isoflurane anaesthesia. *Acta Anaesthesiol Scand* 1993; **37** (8): 730–736.

[26] Wandell CH, Neff S, Bohrer H, Motsch J, Bach A, Martin E. Emergence characteristics after sevoflurane versus propofol anaethesia in adult out patients. *Br J Anaesth* 1994; **72**: 8 (S1).

[27] Lebenbom-Mansour MH, Pandit SK, Kothary SP, Randel GI, Levy L. Desflurane versus propofol anaesthesia: a comparitive analysis in out-patients. *Anaesth Analg* 1993; **76** (5): 936–941.

[28] Van-Hemelrijck J, Smith I, White PF. Use of desflurane for outpatient anaesthesia. A comparison with propofol and nitrous oxide. *Anaesthesiology* 1991; **75** (2): 197–203.

[29] Wrigley SR, Fairfield JE, Jones RM, Black AE. Induction and recovery characteristics of desflurane in day case patients: a comparison with propofol. *Anaesthesia* 1991; **46** (8): 615–622.

[30] White PF. Studies of desflurane in out-patient anaesthesia. *Anaesth Analg* 1992; **75**: 547–554.

[31] Apfelbaum JL, Grasela TH, Hug CC et al. The initial clinical experience of 1819 physicians in maintaining anaesthesia with propofol: characteristics associated with a prolonged time to awakening. *Anaes Analg* 1993; **77** (4 Suppl): S10–S14.

[32] Hitchcock M, Ogg TW. Quality assurance in day case anaesthesia. *Ambulatory Surg* 1994; **2**: 193–204.

[33] Rosenberg MK, Bridge P, Brown M. Cost comparisons: a desflurane versus a propofol based general anaesthetic technique. *Anaesth Analg* 1994; **79** (5): 852–855.