Propofol intravenous anaesthesia for neurosurgery

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Summary

Twenty-three patients undergoing a wide variety of neurosurgical procedures were anaesthetised using fentanyl and propofol (Diprivan; Stuart Pharmaceuticals) for induction and a continuous infusion of propofol with 50% nitrous oxide for maintenance of anaesthesia. All patients were premedicated with midazolam, and hypotensive anaesthesia was employed using labetalol. Alcuronium was used to facilitate intubation and ventilation. The quality of anaesthesia and surgical conditions were good. A rapid, smooth recovery was obtained in 22 patients.

The advent of a new intravenous agent, propofol (2,6 diisopropylphenol) (Diprivan; Stuart Pharmaceuticals), has facilitated the use of continuous intravenous anaesthesia and may have some important advantages in neuro-anaesthesia. Providing good anaesthesia for neurosurgery requires constant attention to the viability of the brain. Drugs and techniques can by direct and indirect mechanisms produce catastrophic changes in intracranial pressure.14

The requirements of good neuro-anaesthesia are: (i) a perfectly still patient who may have to remain in an unusual position for several hours; (ii) a perfect airway with adequate ventilation and no expiratory resistance; (iii) low venous pressure; (iv) minimal bleeding; (v) a slack brain; (vi) the absence of coughing and straining from induction through to recovery; and (vii) a rapid return to consciousness.

While these requirements have in the past been partially achieved by neurolept, volatile and balanced anaesthesia, these techniques are imperfect owing either to respiratory depression secondary to narcotics, increased intracranial pressure and increased cerebral blood flow secondary to volatile anaesthetics or prolonged awakening time.

Propofol is a substituted phenol which has anaesthetic properties when given intravenously. It is presented as a white, aqueous isotonic emulsion which contains 10 mg propofol/ml. The vehicle contains soya bean oil and purified egg phospholipide. Preliminary clinical studies performed in West Germany,3 Italy and France5 showed that propofol causes a dose-dependent reduction in intracranial pressure and reduces both cerebral blood flow and cerebral metabolism. The brain retains its reactivity to changes in arterial carbon dioxide tension. Studies are at present underway in Belgium, Finland, France, Germany, Holland, Italy and the UK investigating the use of propofol in suspected acute myocardial infarction. Eur Heart J 1985; 6: 190-198.

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for thermocoagulation of the trigeminal ganglion, for severe head injury, neuroradiology, and the effects of continuous infusions on cerebral blood flow and metabolism (personal communications). The positive results and minimal complications encountered in these studies prompted us to use propofol as the sole anaesthetic with 50% nitrous oxide for both induction and maintenance in a clinical trial for neuro-anaesthesia.

Patients and methods

Twenty-three patients (12 men and 11 women; age range 24 - 68 years) were included in the trial. Written informed consent was obtained from each patient. Those with abnormal renal or hepatic function or a history of atopy as determined by pre-operative history and examination were excluded.

The surgical procedures included 13 craniotomies, 7 spinal operations, 2 ventriculoperitoneal shunts, and 1 embolisation of an arteriovenous anomaly which was performed under screening in the radiography department.

The craniotomies, 2 of which involved posterior fossa decompressions performed in the sitting position, were as follows: clipping cerebral aneurysms 2, excision of cerebral tumours 4, evacuation of subdural haematoma 2, hypophysectomy 1, excision of acoustic neuroma 1, excision of chordoma 1, excision of orbital tumour 1, and excision of arteriovenous anomaly 1.

The spinal surgery comprised: lumbar laminectomy and dissection 4, cervical decompression and fusion 2, and excision of spinal cord tumour 1.

The duration of surgery varied between 1 hour 30 minutes and 7 hours. All surgery was performed by the same surgeon (E.R.L.), and all anaesthesia was given by the same anaesthetist (M.F.).

For pre-medication patients received either oral midazolam 15 mg if their weight exceeded 45 kg or oral midazolam 7.5 mg if their weight was less than 45 kg 1 hour before coming to theatre.

Propofol has little or no analgesic effect at anaesthetic concentrations. It may also cause localised pain on injection if given rapidly into a small vein. To prevent this discomfort and to facilitate a smooth induction with minimal haemodynamic response to intubation, fentanyl 1.875 µg/kg was given intravenously 1 minute before induction.

Induction of anaesthesia was performed with propofol 2 mg/kg given intravenously over 20 - 25 seconds. After the patient had lost consciousness alcuronium 0.2 mg/kg was given to facilitate endotracheal intubation and mechanical ventilation. No further muscle relaxation is usually required for neurosurgery.\(^3\)

Anaesthesia was maintained with an infusion of propofol. Inhalation of 50% nitrous oxide was used to supplement the anaesthesia. Although many other studies have reported using 66% nitrous oxide or more, a high percentage of nitrous oxide may cause a rise in intracranial pressure.

The infusion rate was 0.15 mg/kg/min for the first 30 minutes, this was then reduced to 0.1 mg/kg/min for the next 1½ hours and subsequently reduced further to 0.075 mg/kg/min for the duration of anaesthesia. This decremental infusion rate was designed to ensure a blood level of propofol which would always exceed the minimum anaesthetic concentration (Fig. 1). The depth of anaesthesia was monitored clinically and by electro-encephalography. Blood propofol levels were not measured.\(^11\)

Patients were mildly hyperventilated on an Elema 900c ventilator with a minute ventilation of 120 - 140 ml/kg. The fraction of inspired oxygen was 0.5 (a lesser percentage is considered unsafe for hypotensive anaesthesia at an altitude of ± 800 m). Mild hyperventilation was confirmed by capno-

![Theoretical infusion profile of propofol.](image-url)

**Fig. 1.** Theoretical infusion profile of propofol. Induction 2 mg/kg; infusion 0.15 mg/kg; the minimum anaesthetic concentration range is represented by the horizontal shaded area (modified from Crockshott\(^3\)).

graphy (partial arterial carbon dioxide pressure 28 mmHg). Humidification was achieved with a Fisher-Paykel humidifier.

Although spinal surgery requires a greater depth of anaesthesia than intracranial surgery, both cause relatively little pain once the skin has been opened. Repeat bolus doses of fentanyl 50 - 100 µg were given before skin incision.

Controlled hypotension to a systolic pressure of 80 - 90 mmHg was used in all patients. Propofol may lower both the heart rate and blood pressure when it is used for induction and maintenance of anaesthesia. This property, although desirable for a planned hypotensive technique, is not reliable or consistent enough to obviate the use of other hypotensive agents. Controlled hypotension was achieved by giving bolus doses of labetalol 4 - 8 ml every 30 - 45 minutes when required (the duration of hypotension provided by labetalol varies from 30 to 45 minutes). The rate of propofol infusion was controlled by an Ivac 531 infusion pump.

All patients had ECG and capnograph monitoring. Blood pressure was monitored every 3 minutes with a Dinamap vital signs monitor. Urinary output and temperature were also monitored. Excessive heat loss was prevented by the use of a thermomat 2000 warming blanket and a reflective plastic sheet (space blanket).

In addition, patients undergoing intracranial surgery had electro-encephalographic and electromyographic neuromuscular monitoring with a Datex anaesthetic and brain activity monitor (ABM). The ABM was not used in patients having spinal surgery since they were operated on in a prone jack-knifed position which makes access to the patient's head cumbersome and difficult.)

Patients having a cerebral aneurysm clipped or excision of an arteriovenous anomaly had their blood pressure monitored continuously via an indwelling radial artery catheter. Central venous pressure monitoring was performed when the sitting position was used, the central line also serving as an additional safety measure in the event of air embolism.

Approximately 5 minutes before insertion of the final skin sutures the infusion was stopped. Neuromuscular block was reversed when necessary with an appropriate dose of neostigmine and atropine and the patient was ventilated with 100% oxygen.
Results

Induction of anaesthesia was successful in all patients; mild discomfort at the injection site occurred in 3. No excitatory phenomena, airway obstruction, hiccup or tremor was observed. A transient rise in blood pressure and heart rate of approximately 10% occurred in 3 patients after intubation, but decreased to less than pre-intubation levels within 5 minutes. Maintenance was extremely smooth. One patient moved 2 minutes after the infusion was discontinued in anticipation of an earlier finish to surgery than actually took place. Apart from this, the quality and depth of anaesthesia as judged by the anaesthetist and surgeon was good in all patients. No other changes suggestive of light or inadequate anaesthesia were seen either clinically or by the ABM. In craniotomies the brain was slack. There was minimal bleeding (which we attribute to the hypotensive technique) in all cases. Induction of anaesthesia resulted in an 8 - 12% decrease in mean arterial pressure of 20 patients compared with the pre-operative level.

Recovery, determined by the patient's ability to open his eyes on command, was rapid and smooth (8 - 14 minutes) after termination of the infusion. Seventeen patients were fully orientated — determined by ability to give name, address, date and location — within 20 minutes of termination of anaesthesia. One patient with a very large cerebral tumour and marked cerebral oedema had delayed recovery, but was fully awake 3 hours postoperatively.

No patients experienced awareness (which was explicitly enquired about at the routine postoperative visit) and no venous sequelae, such as thrombosis or phlebitis, were noted up to 24 hours after surgery. No cardiac arrhythmias were noted, but bradycardia (defined as a pulse rate below 55) occurred in 17 patients due to the combined effects of fentanyl and β blockade.

Discussion

The technique of continuous intravenous anaesthesia is gaining in popularity as shorter-acting, less toxic intravenous hypnotic and analgesic agents become available. 

This clinical trial showed that propofol is an eminently suitable agent for continuous intravenous anaesthesia in neurological patients. Induction was smooth, rapid and free from excitatory phenomena, maintenance was universally good and devoid of untoward effects. Cardiovascular depression occurred but was not clinically significant and complemented the anaesthetic technique. Awakening was smooth, rapid and excitement-free.

Continuous intravenous anaesthesia has considerable theoretical attractions for neurosurgery which have thus far been borne out in clinical practice. The theatre staff appreciated the pollution-free atmosphere by subjectively feeling less lethargic at the end of the day (volatile agents still spill into the theatre atmosphere unless the scavenging unit is perfect). The technique is easy to perform and, although expensive, the cost is not excessive when compared with conventional inhalational techniques.

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REFERENCES