Special Article

Parkinson's disease and anaesthesia

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ABSTRACT

Parkinson's disease (PD), one of the most common disabling neurological diseases, affects about 1% of the population over 60 years of age. It is a degenerative disease of the central nervous system caused by the loss of dopaminergic fibers in basal ganglia of the brain. PD is an important cause of perioperative morbidity and with an increasingly elderly population, it is being encountered with greater frequency in surgical patients. Particular anaesthetic problems in PD include old age, antiparkinsonian drug interaction with anaesthetic drugs and various alterations in the respiratory, cardiovascular, autonomic, and neurological systems. This brief review focuses on the preoperative, intraoperative, and postoperative anesthetic management of PD and gives a brief account of intraoperative exacerbation of PDs and anesthetic management of stereotactic pallidotomy.

Key words: Intraoperative, Parkinson's disease, postoperative management, preoperative assessment

INTRODUCTION

Parkinsonism is the name given to a clinical syndrome comprising impairment of voluntary movement (hypokinesia), rigidity, and tremor. Because of the characteristic stooped posture and chaplinesque shuffling, Parkinson's disease (PD) has been called "the happy disease."[1] The characteristic pathological feature is the destruction of dopamine-containing nerve cells in substantia nigra of basal ganglia.[2]

PD occurs worldwide affecting all ethnic age groups. Parkinson's disease affects >1 million individuals in the United States. Its peak age of onset is in sixties (35–65 years) and the course of illness ranges from 10 to 25 years. Approximately 0.3% of the general population and 3% of the population above 65 years have PD.[2]

In India, community-based prevalence studies show a prevalence rate of 7–328/1,00,000 population over 50 years of age (0.3%). Age- and sex-specific prevalence in India showed a progressive increase in rate along with aging in both genders after the fourth decade but peak rate was observed in the eighth decade in women and beyond the eighth decade in men. It is also more common in females in India.[3]

PREOPERATIVE MANAGEMENT

Preanaesthetic check-up includes the following:

1. Diagnosis and duration of disease
2. Assessment of associated changes in various systems
3. The surgical procedure intended (elective or emergency)
4. Antiparkinsonian drugs the patient is taking and effects of the drugs and the potential interactions with anesthetic drugs
5. Preoperative continuation of levodopa
6. Premedication and acid aspiration prophylaxis

A diagnosis of PD can be made with some confidence in patients who present with at least two of three cardinal signs (primary symptoms)—rest tremor, rigidity, and bradykinesia.[4]

ANESTHETIC IMPLICATIONS

As most of the affected people are above 65 years, they present with geriatric problems, such as surgery for prostrate, incidental general surgical procedures, cataract, gynecological surgeries, and so on.

Autonomic dysfunction is present and can

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produce diverse manifestations, such as orthostatic hypotension, sialorrhea, constipation, incontinence, and frequency, excessive sweating, and seborrhea.[2,4] Autonomic instability can lead to sudden, exaggerate or uncertain response to central neuraxial blockade.

Respiratory dysfunction results from the uncoordinated involuntary movement as a result of rigidity and muscle weakness. Also pharyngeal muscle weakness leads to increased retention and improper impaired expulsion of respiratory secretions and can cause perioperative aspiration pneumonia.[5,6]

Gastrointestinal symptoms include loss of appetite as a result of old age, depression, or medications-induced nausea and vomiting, which lead to loss of weight. These people are predisposed to increased incidence of gastric stasis and gastroesophageal reflux.[5,6] So preoperative acid aspiration prophylaxis is desired.

Neuropsychiatric symptoms include changes in mood (depression), cognition and behavior. Psychotic symptoms include delusions and hallucinations. These symptoms can lead to postoperative emergence reactions and with associated tremors and rigidity can lead to dilemma at the time of extubation.[2,4-6]

DRUG INTERACTIONS

Patients of long duration parkinsonism are on a variety of drugs which have potential interactions with anesthetic drugs and techniques. Some of these are discussed here.

Patients on levodopa treatment will have severe nausea and vomiting and with associated depression and old age, are more prone to be dehydrated and hypovolemic. So adequate fluid management is to be done in perioperative period.

Levodopa acting through a central mechanism contributes to hypotensive effect. Direct-acting dopamine agonists, such as bromocriptine and lisuride, may precipitate hypotension by causing peripheral vasodilation.[7] Use of older antidepressants, such as amitriptyline and other tricyclic antidepressants, may cause orthostatic hypotension.

In patients on levodopa therapy, mono amino oxide (MAO) inhibitors are contraindicated and sympathomimetics should be used with caution as these can cause an acute rise in blood pressure.[8] For patients taking levodopa, halothane which sensitizes the heart to the action of catecholamines, should be avoided as there is potential for precipitating arrhythmias.

MAO-inhibitors inhibit the metabolism of narcotics in the liver, so 20%–25% of the usual dose is advised. Serotonin syndrome (autonomic instability with hypertension, tachycardia, hyperthermia, hyperreflexia, confusion, agitation, and diaphoresis) occurs when meperidine is given to patients receiving antidepressants (MAO-inhibitors, fluoxetine). There are reports of agitation, muscle rigidity, and hyperthermia in patients receiving meperidine and selegiline, so this combination should be avoided.[9]

Drugs that precipitate or exacerbate PD should be avoided, including phenothiazine, butyrophenone, and metoclopramide.[10,11]

Patients with PD have an aggravation of symptoms if is any super added illness and therefore infections should be promptly treated and surgery avoided unless absolutely necessary.[2,4]

At least 65% of the patients on levodopa (without selegeline or bromocriptine) will develop long-term side effects in varying severity after 2–5 years:

A) In wearing off effect, the duration during which the drug is effective becomes progressively less. And in such cases, the total daily dose should be given at more frequent intervals with a concomitant decrease in the amount of each dose.[2,4]
B) In the on–off effect, the patient fluctuates between on period with normal activity and off period with a feature of akinesia and rigidity. These fluctuations are sudden, difficult to predict, and not related to timing of intake and are difficult to manage as increased doses of L-dopa may result in confused states.[2,4]

These side effects may be due to progression of disease or improper absorption of L-dopa. Taking note of these is important for anesthesiologist as intraoperative exacerbation of symptoms may occur if the timing of levodopa dose is not adjusted properly in the preoperative period.

Preoperative use of levodopa

Patients with advanced Parkinson's disease are at risk for exacerbations in the perioperative period. The timing of doses of Parkinson's medication is very important, as abrupt withdrawal of drugs can often cause a very sudden return or even worsening of symptoms and in

some cases can lead to the development of a condition known as neuroleptic malignant syndrome, which can be very dangerous. The half-life of levodopa is 1–3 h and so interruption should be as brief as possible, and therapeutic administration should be continued through the morning of surgery with sips of water.[12] As it is absorbed from the proximal small bowel and thus has to first traverse the stomach making administration of tablets through gastric tube suboptimal or ineffective, because patients with Parkinson's often have delayed gastric emptying. As such a duodenal feeding tube may be necessary when a prolonged period of normal feeding is expected. Patients may self-administer additional levodopa, so it is important to find out exactly how much they are taking.

Enteral levodopa has a clear advantage over intravenous levodopa and should be preferred. Treatment with and drug titration of levodopa for intravenous administration alone may be dangerous during general anesthesia because of interactions with anesthetic agents. It may increase the risk of a variety of arrhythmias or hypertension. These side effects of levodopa are mediated through its metabolite, dopamine.[13]

INTRAOPERATIVE ANESTHETIC MANAGEMENT

Anesthetic technique depends on many factors, such as the intended surgical procedure, patient consent, surgeon's preference, and co-existing risk factors.

Advantages of regional anesthesia over general anesthesia

1. Regional anesthesia allows for communication of the subjective feelings accompanying Parkinson's disease attacks, thereby prompting earlier treatment
2. The muscle-relaxing effects of general anesthesia (GA) and neuromuscular blockers are avoided. These mask the myopotentials, which are usually the first sign of intraoperative exacerbation
3. Residual GA or neuromuscular blocker, which may delay diagnosis and treatment of an exacerbation is avoided
4. Inhalational anesthesia in combination with adjunctive drugs (such as opioids) can precipitate overt symptoms of primary parkinsonism in a patient
5. The high incidence of nausea and vomiting associated with GA prevents effective administration of oral medications and exacerbation can occur in the postoperative period
6. Better pain relief and attenuation of surgical stress response with regional anesthesia
7. Patients with PD are more prone to chest infection before and after surgery under GA as these patients may have difficulty in clearing secretions because of ineffective cough effort and impaired swallowing

Disadvantages of regional anesthesia over general anesthesia

1. Regional anesthesia will not eliminate Parkinson's symptoms, such as tremor or rigidity, except in the areas directly affected by the anesthetic.
2. Tremor can interfere with some monitoring device and makes it more difficult to interpret.
3. If the surgery is delicate, the surgeon may want the patient to be absolutely still.
4. The surgical procedure may not be possible under regional anesthesia.

Sedation

If sedation is required, diphenhydramine is useful particularly for ophthalmic procedures. It has central anticholinergic activity, which is advantageous in PD where tremor can render surgery difficult.[14]

GENERAL ANESTHESIA

The drug effect and interactions of various drugs used in general anesthesia are discussed in brief below.

Premedication

Preferred anticholinergic is glycopyrolate bromide as it doesn't cross blood–brain barrier. Ondansetron, a serotonin antagonist appears to be a safe alternative to droperidol for prevention or treatment of emesis in these patients.

Intravenous induction agents

Thiopental sodium

Thiopentone decreases dopamine release from striatal synaptosomes and parkinsonian episodes have been described in patients receiving thiopental.[15]

Ketamine

PD is associated with impaired baroreceptor reflexes and ketamine use can produce unprecedented blood pressure responses. So it is theoretically contraindicated. The likelihood of co-existing heart disease in elderly patients with PDs, however, makes the use of ketamine less attractive.[16]

In a case report in which ketamine provided immediate resolution of dyskinesias in a patient with severe PD, the authors suggested that it is specifically the N-Methyl-D-Aspartate (NMDA) antagonist properties of low-dose ketamine, titrated to effect, that might provide optimal patient comfort and control of symptoms in the preoperative setting in patients with severe PD. Furthermore, anesthesiologists should consider low-dose ketamine (0.1–0.5 mg/kg IV) as a safe, novel, and useful temporary adjunct to long-term treatment when doses of dopamine-based medications are missed within the perioperative setting.[17]

Propofol

Propofol, like other anesthetics, potentiates Gama-amino butyric acid (GABA) ergic transmission. Furthermore, propofol appears to interact with excitatory amino acid transmission. It inhibits the glutamate-dependent calcium entry in rat synaptosomes and the adenosine triphosphate-dependent uptake of glutamate.[18] It may also have a slight inhibitory effect on the release of glutamate. Propofol suppresses *N*-methyl-O-aspartic acid receptor channels in clinically relevant concentrations.[19]

Facilitatory effects of propofol on GABAergic transmission and inhibitory effects on glutamate transmission could be responsible for the antiparkinsonian effect of propofol, as well as for the induction of involuntary movements. This might particularly be so for propofol-induced dyskinesias seen in patients with Parkinson's disease.[20]

Opioid/Narcotics

The incidence of opioid-induced skeletal muscle rigidity (generalized hypertonus of skeletal muscles) depends on the opioid (most common with fentanyl) and the dose and rapidity of opioid administration.[21] Inhibition of the striatal release of GABA and increased dopamine production are the likely explanation for rigidity. Skeletal muscle rigidity, especially at the thoracic and abdominal muscles, is common when large doses are administered rapidly as in opioid induction.[21] Acute dystonia has been described after alfentanil was given to untreated Parkinson's patients.[22] Morphine has dual effect, it inhibits dyskinesia in lower doses and increases it in higher doses.

There are prior reports of postoperative muscle rigidity in patients who have an established diagnosis of Parkinson's disease, especially after the use of fentanyl and droperidol. Even in normal patients, generalized perioperative rigidity can occur after moderate to high dosages of fentanyl, sufentanil, or Innovar. Opioid-induced muscle rigidity responds to neuromuscular blockade. Opiod-induced rigidity occurs probably by the inhibition of dopamine release. This hypothesis is consistent with observations that patients with Parkinsonism are predisposed to this narcotic side effect.[23] Attempts to prevent fentanyl-induced rigidity with amantadine, a stimulant for dopamine release, have not been successful.[24] The use of potent non steroidal anti inflammatory drugs (NSAIDS) and multimodal has avoided the need for narcotic analgesics in these patients.

Neuromuscular blocking agents

There are conflicting reports on the use of succinylcholine in Parkinson's disease. It has been associated with sudden cardiac arrest and in a case series its use was found to be associated with no adverse effects.[25,26] There are no reported cases of non-depolarizing neuromuscular blocking drugs worsening the symptoms of PD.

Inhalational anesthetics

There are many mechanisms that explain the depressant effect of inhalational anesthetics in all situations. Various mechanisms proposed include direct myocardial depression, Inhibition of central nervous system (CNS) sympathetic outflow, peripheral autonomic ganglionic blockade, decreased influx of calcium, decreased cAMP formation, decreased release of catecholamines. Isoflurane is unique as it possesses mild beta-adrenergic agonist properties and so maintains cardiac output.[21] As Parkinson's patients are usually of old age, dehydrated, and hypovolemic, perioperative hypotension is a real possibility. If vasopressors are needed, a direct-acting agent, such as phenylephrine hydrochloride, is indicated. Prior drug therapy that alters the sympathetic nervous system (antihypertensives, beta-blockers, calcium channel blockers) make the heart more vulnerable to depressant effects of inhalational anesthetics.[21]

Potent inhalational anesthetics may increase brain extracellular dopamine concentrations during general anesthesia. Because the transport of dopamine by synaptosomes is impaired during and after exposure to halothane or isoflurane, there may be decreased dopaminergic transmission as well as accumulation of extracellular dopamine during inhalational anesthesia because of simultaneous dopaminergic receptor

blockade and depressed neuronal release and reuptake of dopamine, thereby precipitating an exacerbation intraoperatively.[23]

Emergence from anesthesia

Emergence from anesthesia, even in healthy patients, is often marked by the transient appearance of a variety of what are otherwise considered to be pathological neurological reflexes, including hyper-reactive stretch reflexes, ankle clonus, the Babinski reflex, and decerebrate posturing.[27] Shivering is common after general anesthesia and regional analgesia and should be distinguished from parkinsonian symptoms.

Increased incidence of postoperative bronchospasm after reversal with neostigmine and glycopyrolate is noted. Patients with PD have obstructive dysfunction due to parasympathetic overactivity, which may make them susceptible to muscarinic effects of neostigmine and probably can cause postoperative bronchospasm. Gastrointestinal dysfunction is common in patients with PD and usually presents with dysphagia and sialorrhea.[28] Accordingly the patients must be considered at risk for aspiration pneumonitis. Postoperatively, patients with PD are more likely to develop confusion and hallucinations.[29]

INTRAOPERATIVE EXACERBATION OF PARKINSON'S DISEASE

Manifestations begin with fine skeletal muscle tremors that are grossly unrecognizable. Under regional anesthesia an acute exacerbation may present with patient remaining awake and alert and complaining of subjective feelings of discomfort. Examination of the patient's chest and upper extremities reveals fine tremors that progress to more gross tremors and rigidity within 5–15 min. Skeletal muscle activity progressing to rigors can hinder the quality of surgical repair and prolong the operating time. In electrocardio gram (ECG) a coarse fibrillatory pattern may be seen, which may be due to fine skeletal muscle tremors. This can be mistaken for ventricular fibrillation and the initial response to perform electrical defibrillation is unnecessary and potentially deleterious.

Arterial blood pressure, heart rate, respiratory rate, and oxygen saturation are usually unchanged. Levodopa and carbidopa can be given orally with a sip of water while surgery continued. Motor activity and the subjective feelings of discomfort usually resolve approximately 20 min after initiating therapy.[27]

Patients with advanced Parkinson's disease are at risk for exacerbations in the perioperative period. Even with patients complying with perioperative levodopa therapy, sometimes due to an unforeseen delay in the time of surgery, signs and symptoms of exacerbation may be seen intraoperatively.

Prevention of an acute exacerbation is by administering oral levodopa approximately 20 min before inducing anesthesia and may be repeated intraoperatively and postoperatively every 2nd hourly, by giving it through nasogastric tube with tip placed in proximal small bowel.

Postoperative ileus represents a serious problem for patients with severe Parkinson's disease. Levodopa is absorbed from the proximal small bowel and therefore is useless as a suppository. Absorption occurs rapidly from the gastrointestinal tract and can be used in many postlaparotomy patients. For those patients in whom intestinal absorption does not take place only diphenhydramine and benztropine are available for Parkinson's disease treatment.

ANESTHETIC MANAGEMENT FOR STERIOTACTIC PALLIDOTOMY/THALAMOTOMY

Classically local anesthesia (LA) with minimal or no sedation has been used for patients undergoing stereotactic procedures. This allows for patient participation in target localization and immediate observation of effects of test and lesion.[30,31] Antiparkinsonian mediations are withheld for 12–24 h prior to surgery. Therapy for concurrent diseases must be continued till the day of surgery.

Under LA, in magnetic resonance imaging (MRI) suite stereotactic frame applied. Extra padding and rolls can make the patient more comfortable. Also these patients are very motivated to co-operate, unless there is dementia present. LA again is used to do burr hole and if the patient becomes agitated, midazolam can be titrated to desired effect. It is important that level of sedation does not impair co-operation or interfere with communication between surgeon and patient. Age, varying levels of dementia, fatigue, and cumulative effects of medication make it necessary to titrate the drugs slowly.[32,33] Since propofol may elicit abnormal movements and may at times improve parkinsonian tremor, it might not be ideally suited for patients with movement disorders undergoing functional stereotactic neurosurgery.[34]

Major concern intraoperatively is intracranial haemorrhage. It manifests as rapid decrease in conscious level and haemiparesis. Emergency intubation may be necessary. Prior to surgery, a plan should be agreed on between surgeon and anesthesiologist for intubation. Ideally, it should be done without removing stereotactic frame.

Other complications include hypertension, motor deficit, visual field deficit, aphasia, and infection.[35] Centrally acting beta-blockers, such as propranolol, should not be used to decrease blood pressure (BP) intraoperatively as these can decrease the tremor intensity. However, if necessary drugs, such as labetolol, that does not cross blood brain barrier (BBB) can be used.

POSTOPERATIVE CONSIDERATIONS

Strict vigilance of the hemodynamic and respiratory parameters in the immediate postoperative period as increased chances of respiratory depression present with GA.

Care must be taken to start antiparkinsonian drugs as soon as possible, either through the nasogastric tube or orally, if patient can swallow medication with sips of water.

Proper postoperative analgesia with multimodal analgesics or with strong NSAIDs should be provided according to the type of surgery.

Chest physiotherapy and breathing exercises for all the thoracic and upper abdominal surgeries should be instituted to avoid respiratory infections.

CONCLUSION

Parkinson's disease is an increasingly common disease of elderly patients who present a particular anesthetic challenge. With increasing life span of general population and improved medical and diagnostic facilities, it is more likely for any anesthesiologist to encounter an elderly patient with Parkinson's disease. It is the duty of every practicing anesthesiologist to become familiar with special demands and needs of patients with Parkinson's disease (old age, co-existing diseases, drug-induced aberrancies, various drug interactions, airway abnormalities, and so on), this will go a long way in enhancing patient comfort and satisfaction and in improving perioperative anesthetic and surgical outcome.

REFERENCES

1. Kelly PJ. Pallidotomy in Parkinson's disease. Neurosurgery 1995;36:1154-7.
2. DeLong MR, Juncos JL. Parkinson's Disease and Other Movement Disorders. In: Kasper DL, Fauci AS, Longo DL, Braunwald E, Hauser SL, Jameson JL. Harrison's Principles of Internal Medicine, 17th ed. New York: McGraw-Hill Medical Publishers; 2008. p. 2406-17.
3. Gourie – Devi M, Gururaj G, Satishchandra P, Subbakrishna DK. Prevalence of neurological disorders in Bangalore (India): A community based study with an urban–rural comparison. Neuroepidemiology 2004;23:261-8.
4. Nicholson G, Pereira AC, Hall GM. Parkinson's disease and anaesthesia. Br J Anaesth 2002;89:904-16.
5. Roizen MF, Fleisher LA. Anesthetic implications of concurrent diseases. In: Miller RD editor. Miller's Anaesthesia, 7th ed. New York: Churchill-Livingstone; 2010. p. 1167-50.
6. Stoelting RK, Dierdorf SF. Disease of the Nervous System. In: Stoelting RK, Dierdorf SF editors. Anesthesia and Co-Existing Disease, 4th ed. Philadelphia: Churchill Livingstone; 2002. p. 233-98.
7. Robert K. Stoelting, Simon C. Hillier. Drugs used for treatment of Parkinson's Disease. In: Robert KS, Simon CH editors. Pharmacology and Physiology in Anaesthetic Practice, 4th ed. Philadelphia: Lippincott Williams and Wilkins; 2006. p. 580-4.
8. KD Tripathi. Anti Parkinsonian drugs. In: Tripathi KD editor. Essentials of Medical Pharmacology, 6th ed. New Delhi: Jaypee Publishers; 2004. p. 381-9.
9. Zornberg GL, Bodkin JA, Cohen BM. Severe adverse interaction between pethidine and selegiline. Lancet 1991;337:246.
10. Avorn J, Gurwictz JH, Bohn RL, Mogun H, Monane M, Walker A. Increased incidence of levodopa therapy following metoclopramide use. JAMA 1995;274:1780-2.
11. Quinn NP. Classification of fluctuations in patients with Parkinson's disease. Neurology 1998;51:S25-9.
12. Reed AP, Han DG. Intraoperative exacerbation of Parkinson's disease. Anesth Analg 1992;75:850-3.
13. Goyal N, Wajifdar H, Jain A. Anaesthetic management of a case of Parkinson's disease for emergency laparotomy using enteral levo-dopa intraoperatively. Indian J Anaesth 2007;51:427-8.
14. Stone DJ, Difazio CA. Sedation for patients with Parkinson's disease undergoing ophthalmic surgery. Anesthesiology1988;68:821.
15. Muravchick S, Smith DS. Parkinsonian symptoms during emergence from general anaesthesia. Anesthesiology 1995;82:305-7.
16. Hetherington A, Rosenblatt RM. Ketamine and paralysis agitans. Anesthesiology1980;52:527.
17. Wright JJ, Goodnight PD, McEvoy MD. The utility of ketamine for preoperative management of a patient with Parkinson's disease. Anaesth Analg 2009;108:980-2.
18. Anderson BJ, Marks PV, Futter ME. Propofol-contrasting effects in movement disorders. Br J Neurosurg 1994;8:387-8.
19. Bianchi M, Battistin T, Galzigna L. 2,6-Diisopropylphenol, a general anesthetic, inhibits glutamate action on rat synaptosomes. Neurochem Res 1991;16:443-6.
20. Yamakura T, Sakimura K, Shimoji K, Mishina M. Effects of propofol on various AMPA-, kainate- and NMDA-selective receptor channels expressed in *Xenoptls oocytes*. Neurosci Lett 1995;188:187-90.
21. Dierdorf SF: Rare and coexisting diseases. In: Barash PG, Cullen BF, Stoelting RK. Clinical Anesthesia. 2nd ed. Philadelphia: JB Lippincott; 1992. p. 563-87.
22. Mets B. Acute dystonia after alfentanil in untreated Parkinson's disease. Anesth Analg 1991;72:557-8.
23. Mason LJ, Cojocaru TT, Cole D J. Surgical intervention and anaesthetic management of the patient with Parkinson's disease. Int Anesthesiol Clin 1996;34:133-50.

24. Vacanti CA, Silbert BS, Vacanti FX. Fentanyl-induced muscle rigidity as affected by pretreatment with amantadine hydrochloride. J Clin Anesth 1992:4:282-4.
25. Gravlee GP. Succinylcholine-induced hyperkalaemia in a patient with Parkinson's disease. Anesth Analg 1980; 59:444-6.
26. Muzzi DA, Black S, Cucchiara RF. The lack of effect of succinylcholine on serum potassium in patients with Parkinson's disease. Anesthesiology 1989;71:322.
27. Rosenberg H, Clofine R, Bialik O. Neurologic changes during awakening from anesthesia. Anesthesiology 1981;54:125-30.
28. Korczyn AD. Autonomic nervous system disturbances in Parkinson's disease. Adv Neurol 1990:53;463-8.
29. Golden WE, Lavender RC, Metzen WS. Acute postoperative confusion and hallucination in Parkinson's disease. Ann Intern Med 1989;111:218-22.
30. Burchiel KJ. Thalamotomy for movement disorders. Neurosurg Clin N Am 1995;6:55-71.
31. Zesiewicz TA, Hauser RA. Neurosurgery for Parkinson's disease. Semin Neurol 2001;21:91-101.
32. Iacono RP, Shima F, Lonser RR, Kuniyoshi S, Maeda G, Yamada S. The results, indications, and physiology of posteroventral pallidotomy for patients with Parkinson's disease. Neurosurgery 1995;36:1118-25.
33. Leitinen LV, Bergenheim AT, Hariz MI. Ventroposterolateral pallidotomy can abolish all parkinsonian symptoms. Stereotact Funct Neurosurg 1992;58:14-21.
34. Krauss JK, Akeyson EW, Giam P, Jankovic J. Propofol-induced dyskinesias in Parkinson's disease. Anaesth Analg 1996;83:420-2.
35. Boyer KL, Bakay RA. The history, theory, and present status of brain transplantation. Neurosurg Clin N Am 1995;6:113-25.

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