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Electroconvulsive Therapy and Related Treatments

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Electroconvulsive therapy (ECT) is a sophisticated medical procedure that uses electrical stimulation applied to the scalp to induce a series of brief, controlled seizures in a patient who is under general anesthesia. ECT is a safe, rapidly acting, and highly effective treatment for certain severe neuropsychiatric disorders, most notably mood disorders (including those in patients with neurological disorders), some forms of schizophrenia, and syndromes such as delirium and catatonia (American Psychiatric Association 2001; U.K. ECT Review Group 2003).

In this chapter, we review the use of ECT as a treatment for neuropsychiatric disorders in elderly patients. We discuss the indications and efficacy, medical physiology, mechanisms of action, contemporary technique, and safety and adverse effects of this important procedure, as well as its unique role in patients with neurological disorders. In addition, we preview some experimental "brain stimulation" therapies that are related to ECT and that may hold promise for the future. These therapies include focal electrically administered seizure therapy (FEAST) and magnetic seizure therapy (MST). Other brain stimulation therapies are discussed in Chapter 11, "Brain Stimulation Therapies: Vagus Nerve Stimulation, Transcranial Magnetic Stimulation, Transcranial Direct Current Stimulation, and Deep Brain Stimulation."

ECT in Geriatric Neuropsychiatric Practice

Although precise data are not available, Hermann et al. (1995) estimated that ~4.9 patients per 10,000 population receive ECT annually in the United States. For years after its introduction in 1938, ECT was used primarily in younger adults because of concerns about its safety in older patients and in those with general medical comorbidity. Refinements in ECT technique (discussed in "Technique of ECT" later in this chapter) have largely obviated those initial concerns so that now a large proportion of patients receiving ECT are elderly, and this number will increase as the population continues to age. Kramer (1985) reviewed patterns of ECT use in California from 1977 to 1983 and found that the probability of receiving ECT increased with age of the patient. Patients ages 65 years and older were given ECT at a rate of 3.86/10,000 population, compared with 0.85/10,000 in those ages 25–44 years. In an analysis of the data on ECT use in California from 1984 to 1994, Kramer (1999) found similar patterns. Babigian and Guttmacher (1984) reviewed a massive data set from the Monroe County (New York) Psychiatric Case Register over three 5-year periods. They found that among patients hospitalized for the first time, those who received ECT were older than those who did not. Lambourn and Barrington (1986) surveyed the use of ECT from 1972 to 1983 in a British population of 3 million and found that ECT use was more common in patients (especially female patients) ages 60 years and older. In a study of 5,729 psychiatric admissions over 3 years, Malla (1988) found that patients who received ECT in general hospitals were significantly older than patients who did not receive ECT. Thompson et al. (1994) analyzed data from the National Institute of Mental Health Sample Survey program for 1980 and 1986, which included representative samples of psychiatric inpatients in the United States. They found that approximately one-third of ECT recipients were ages 65 years and older, a figure far out of proportion to the representation of that age group in the sample (8.2%). Rosenbach et al. (1997) studied a sample (~4,000 people) of Medicare Part B claims from 1987 to 1992 and found an ECT rate of 5.1/10,000 population. In an analysis of inpatient data from the 1993

Healthcare Cost and Utilization Project of the Agency for Healthcare Policy and Research, Olfson et al. (1998) found that ~10% of 22,761 patients admitted to a general hospital with a principal diagnosis of recurrent major depression received ECT that year. Increasing age was one of several patient variables associated with higher ECT use; persons ages 65 years and older were seven times more likely to receive ECT than were persons ages 18–34 years.

Several factors help to explain the frequent use of ECT in elderly patients. First, elderly individuals may be more sensitive to medication side effects, particularly the combination of antidepressants and antipsychotics typically required to treat psychotic depression. Second, evidence suggests that antidepressant pharmacotherapy may be less effective in elderly than in younger patients (Roose et al. 2004). In contrast, increasing age as a variable may be a positive predictor of ECT response (Black et al. 1993; Coryell and Zimmerman 1984; O'Connor et al. 2001; Tew et al. 1999). Third, elderly patients are more likely to have comorbid general medical or neurological disorders, which may complicate the use of psychotropic medications or limit their effectiveness (Mottram et al. 2006). For all these reasons, ECT is a critically important component of the neuropsychiatrist's tool kit used to treat mood disorders in elderly patients. Indeed, several studies have found that the use of ECT is one of the most important variables associated with a positive outcome in later-life depression (Bosworth et al. 2002; Philibert et al. 1995; Rubin et al. 1991; Zubenko et al. 1994). Finally, ECT appears to be at least as cost-effective as pharmacotherapy (Greenhalgh et al. 2005; McDonald 2006), and perhaps even more so in certain settings (Olfson et al. 1998).

Diagnostic Indications and Efficacy

ECT is indicated for the acute treatment of severe mood disorders (including depression or mania), certain forms of schizophrenia, and syndromes such as delirium and catatonia. ECT is also an effective form of continuation treatment for some of these conditions (discussed later in this chapter in "Technique of ECT"). The neurobiological effects of ECT may also prove salutary in other neuropsychiatric syndromes, such as Parkinson's disease (discussed later in this chapter in "ECT in Elderly Patients With Neurological Disorders").

Depression

The most common indication for ECT in all patients, including those who are elderly, remains the acute and maintenance treatment of depression, both major and bipolar. In elderly patients with depression, ECT is typically used as a second-line treatment, after patients have failed to respond to a trial of medication or have exhibited intolerance of the side effects of medication. ECT should be considered a first-line intervention in certain situations, however, such as when the presenting illness threatens the patient's life (e.g., severe suicide risk, severe melancholia with inanition and malnutrition, inability to comply with critical general medical care), when ECT is deemed safer than alternative treatments, or when the patient has a history of response to ECT or a preference for ECT (American Psychiatric Association 2001).

Six randomized controlled trials have found ECT superior to sham ECT in adults with depression (reviewed in Abrams 2002b). A reanalysis of one of these trials (the Nottingham trial; Gregory et al. 1985) found that the efficacy of ECT was also superior to sham ECT in elderly patients with depression (O'Leary et al. 1995). Although a Cochrane Review of the randomized evidence concluded that the data were too sparse to determine the efficacy of ECT in depressed elderly patients (Stek et al. 2003), subsequent reviews, which included the extensive nonrandomized literature, concluded that ECT is indeed effective in the acute treatment of depression in elderly patients (Dombrovski and Mulsant 2007; Flint and Gagnon 2002; Salzman et al. 2002; Van der Wurff et al. 2003).

The reported response rates to ECT among elderly patients with depression range from 63% to 98%, clearly demonstrating that increasing age, per se, does not have a negative impact on the effectiveness of ECT for depressive illness. In fact, evidence suggests that ECT may be even more effective in elderly patients than in younger age groups (O'Connor et al. 2001), and several reports have confirmed the efficacy and safety of ECT even in the "old-old" (the low end of which is variably defined as between ages 75 and 85) (Casey and Davis 1996; Cattan et al. 1990; Gormley et al. 1998; Manly et al. 2000).

ECT is reported to be 20%–45% more effective than pharmacotherapy for depression (see review by Abrams 2002b), as confirmed in two meta-analyses (Janicak et al. 1985; U.K. ECT Review Group 2003). This same therapeutic superiority of ECT over antidepressant pharmacotherapy has also been demonstrated in elderly patients (Folkerts et al. 1997; Salzman et al. 2002). No somatic therapy for depression has been shown to have efficacy superior to that of ECT (Sackeim 2005).

Certain clinical features may predict a particularly robust response to ECT among patients with depression. Data derived largely from mixed-age samples of adults suggest that a particularly good response to ECT is associated with the presence of psychosis, catatonia, pseudodementia, pathological guilt, anhedonia, agitation, and neurovegetative signs (Greenberg and Fink 1992; Hickie et al. 1996; Salzman 1982; Zorumski et al. 1988). These findings were confirmed in a prospective study involving 29 elderly patients (Fraser and Glass 1980), in which guilt, anhedonia, and agitation were identified as positive prognostic signs. In multiple studies, response to ECT has been particularly good in patients with delusional depression, com-

pared with a nonpsychotic group (Hickie et al. 1996; Mulsant et al. 1991; Pande et al. 1990; Petrides et al. 2001; Wilkinson et al. 1993), although other studies have found no difference (O'Leary et al. 1995; Rich et al. 1984a, 1986; Sobin et al. 1996; Solan et al. 1988). Delusions are common in depressed elderly persons, and typically these patients respond poorly to pharmacotherapy. The use of ECT in agitated or psychotic elderly patients may spare them exposure to antipsychotic agents. This consideration is important, given the risks of antipsychotic drugs to induce motor (e.g., tardive dyskinesia), metabolic, and vascular complications in elderly patients (Jenike 1985; see also Chapter 9, "Geriatric Neuropsychopharmacology"). Suicide is a major concern for patients with depression, and the risk of this outcome is particularly high in elderly people (especially men). ECT is rapidly effective against suicidal ideation (Kellner et al. 2005), an advantage that is particularly important to elderly patients, who may respond more slowly to antidepressant medications than do younger patients (Mulsant et al. 2006).

A variety of biological markers for ECT response have been investigated in mixed-age samples, including the dexamethasone suppression test, the thyrotropin-releasing hormone test, and other neuroendocrine tests (Decina et al. 1987; Kamil and Joffe 1991; Kirkegaard et al. 1975; Krog-Meyer et al. 1984; Papakostas et al. 1981; Swartz 1993), as well as polysomnographic studies (Coffey et al. 1988; Grunhaus et al. 1996) and the apolipoprotein E polymorphism (Fisman et al. 2001). None of these laboratory studies appears to provide strong "state-specific" markers for major depressive illness, and data are inconsistent (Devanand et al. 1991) on whether they can be used serially to follow the course of ECT, predict outcome, or predict early relapse.

Several authors have attempted to identify predictors of nonresponse to ECT. In a retrospective study, Magni et al. (1988) compared elderly patients who responded to ECT and those who did not respond and found that physical illness during the index episode, fewer negative life events preceding the onset of the index episode, and prior depressive episodes of long duration were predictive of nonresponse to ECT. Other investigators have found that longer duration of the index episode predicts poorer outcome (Fraser and Glass 1980; Karlinsky and Shulman 1984). Previous courses of ECT and increased age at the time of first treatment with ECT have been linked with a slower response rate to ECT, with no effect on eventual positive outcome (Rich et al. 1984b; Salzman 1982; Shapira and Lerer 1999). There are conflicting data on whether pre-ECT medication resistance predicts nonresponse to ECT (Rasmussen et al. 2007a), with response rates ranging from 28% to 72% depending on the patient sample, definition of "medication resistance," and ECT treatment protocol (Dombrovski et al. 2005). The limited data, however, should not discourage the clinician from initiating a trial of ECT in patients with any of the aforementioned predictors of nonresponse. The fact that patients who receive ECT come from a selected population that is less responsive to antidepressant medication and generally is at greater risk for relapse underscores the value of this treatment for the most difficult-to-treat elderly patients.

Although few studies have directly compared residual depressive symptoms following ECT and following pharmacotherapy, full remission is likely to be more common following ECT (Hamilton 1982). Residual depressive symptoms have a serious impact on the quality of life and may result in chronicity of depression in elderly patients and increase the likelihood of relapse (Prien and Kupfer 1986). A number of studies have suggested that use of ECT is one of the most important variables in predicting a positive outcome of depression in elderly patients, with reduced chronicity, decreased morbidity, and possibly decreased mortality (Avery and Winokur 1976; Babigian and Guttmacher 1984; Philibert et al. 1995; Wesner and Winokur 1989; Zubenko et al. 1994).

Mania

Although extensive clinical experience indicates that ECT is effective for treating both manic and depressed phases of bipolar illness in elderly patients, formal data for this population are lacking. A small number of controlled studies involving relatively young mixed-age samples have found ECT to be superior to drug therapy (Mukherjee 1989; Mukherjee et al. 1988; Small et al. 1988, 1991). ECT appears to be particularly effective in mixed bipolar states and agitated mania, conditions that may become more prevalent as the illness becomes more chronic and refractory (Calabrese et al. 1993). ECT may be particularly suitable for elderly patients who have this more severe form of bipolar disorder. Also, morbidity from ECT is likely to be less risky than the general medical risks of a sustained period of mania in an older person.

Schizophrenia and Other Psychotic Disorders

No controlled data exist on the use of ECT in elderly patients with schizophrenia. ECT has been used in younger patients with this illness, and in these patients several features correlate with good outcome, including the presence of affective or catatonic features, an acute onset of illness with relatively brief duration of illness, and a history of response to ECT (American Psychiatric Association 2001; Braga and Petrides 2005; Tharyan and Adams 2005). ECT does not appear to be very effective for treating the chronic, residual phase of the illness with predominant negative features (Weiner and Coffey 1988). These "deficit" states become more common as the illness progresses (Kaplan and Sadock 2005) and thus may be

highly represented in elderly patients with schizophrenia, although controlled data on this issue are lacking. To the best of our knowledge, there are no systematically collected data on the efficacy of ECT in patients with late-onset functional psychoses, such as late-onset schizophrenia.

Delirium and Catatonia

Although no controlled data have been reported on the use of ECT in patients with delirium (see Chapter 15, "Delirium"), numerous case and clinical series have documented its safety and effectiveness, irrespective of the underlying etiology of the delirium (see Krystal and Coffey 1997 for a review). Indeed, ECT has been used for the management of neuropsychiatric symptoms of delirium in Europe and Scandinavia for decades (Kramp and Bolwig 1981). The use of ECT in patients with delirium is generally reserved for those who have not responded to more standard general medical treatment (American Psychiatric Association 2001).

Catatonia is a potentially life-threatening syndrome whose symptoms overlap with those of delirium (see Chapter 15). A large clinical literature supports the effectiveness of ECT as a safe and rapidly effective treatment for catatonia and related conditions, such as neuroleptic malignant syndrome (Caroff et al. 2007; Fink and Taylor 2003).

Medical Physiology of ECT

The data on the physiology of ECT have been compiled largely from mixed-age adult samples, and to our knowledge, few data focus specifically on the physiology of ECT in elderly patients. Clearly, the myriad physiological changes that accompany an ECT seizure take on particular importance in elderly individuals, in whom general medical illnesses involving multiple organ systems are common. Of greatest importance are the physiological effects of ECT on the brain and the cardiovascular system. As described later in this chapter, modifications in ECT technique may be required in patients with brain or cardiovascular disease (see "Technique of ECT" and "ECT in Elderly Patients With Neurological Disorders").

Cerebral Physiology

With ECT, an electrical stimulus applied to the scalp is used to depolarize cerebral neurons and thereby produce a generalized cerebral seizure. The mechanism by which ECT seizures are propagated is not well understood. Bilateral ECT appears to lead to seizure generalization through direct stimulation of the diencephalon (a subcortical "pacemaker"), whereas seizures induced with unilateral stimulation may begin focally in the stimulated cortex and then generalize via corticothalamic pathways (Staton 1981).

During the initial phase of the induced seizure, electroencephalographic (EEG) activity is variable, consisting of patterns of low-voltage fast activity and polyspike rhythms. These patterns correlate with tonic or irregular clonic motor movements. With seizure progression, EEG activity evolves into a pattern of hypersynchronous polyspikes and waves that characterize the clonic motor phase. These regular patterns begin to slow and eventually disintegrate as the seizure ends, sometimes terminating abruptly in a flat electroencephalogram for several seconds (Weiner and Krystal 1993). The entire seizure typically lasts 30–60 seconds, and preseizure EEG rhythms are typically recovered within 20–30 minutes. It should be noted that although the scalp-recorded electroencephalogram implies that the ECT seizure is an all-or-none phenomenon, in fact the onset, duration, and EEG morphology of the seizure all vary according to the brain structures involved. The interictal (intertreatment) electroencephalogram typically shows mild slowing, particularly in frontal regions. These ictal and interictal EEG features vary with ECT technique (i.e., stimulus waveform, stimulus electrode placement, stimulus dosage, stimulus parameters, and treatment frequency and number), as well as with the patient's age. For example, increasing age is associated with shorter seizure duration; shorter slow-wave-phase duration; weaker overall strength and patterning; and lower early ictal, midictal, and postictal amplitudes (Krystal et al. 1995, 1998).

The ECT-induced seizure is also associated with a variety of transient and benign changes in cerebral physiology (reviewed in Abrams 2002b). In patients with depression, *cerebral blood flow* is typically reduced frontally at baseline, increased during the ECT seizure, and then either increased or decreased relative to baseline after ECT, depending in part on the timing and measurement technique employed. The increase in cerebral blood flow during the seizure produces a brief increase in intracranial pressure that is rarely of clinical consequence but is the reason for extreme caution when ECT is used in patients with space-occupying mass lesions. Studies of cerebral permeability generally confirm that the structural *integrity of the blood-brain barrier* is maintained during ECT, despite the rise in cerebral blood flow. A variety of changes in regional *cerebral glucose metabolism* (measured with positron emission tomography) are reported either during or after ECT (Nobler et al. 2001), but no consistent patterns have emerged. The effects of age on all these cerebral physiological changes have not been described systematically, although in animals, age is associated with increased blood-brain permeability changes after 10 electroconvulsive seizures (Oztas et al. 1990).

Cardiovascular Physiology

ECT results in a marked activation of the autonomic nervous system, and the relative balance of parasympathetic and sympa-

thetic nervous system activity determines the observed cardiovascular effects (Applegate 1997). Vagal (parasympathetic) tone is increased during and immediately after administration of the electrical stimulus, and this may be manifested by bradycardia or even a brief period of asystole. With development of the seizure, activation of the sympathetic nervous system occurs, resulting in a marked increase in heart rate, blood pressure, and cardiac workload. Peripheral stigmata of sympathetic activation, including piloerection and gooseflesh, may also be observed. The tachycardia and hypertension continue through the ictus and generally end along with the seizure. Near or shortly after the end of the seizure, there may be a second period of increased vagal tone, which may be manifested by bradycardia and various dysrhythmias, including ectopic beats. As the patient awakens from anesthesia, there may be an additional period of increased heart rate and blood pressure as a result of arousal and further sympathetic outflow (Welch and Drop 1989).

The cardiovascular responses during ECT combine to produce an increase in myocardial oxygen demand and a decrease in coronary artery diastolic filling time. Transient electrocardiographic changes in the ST and T waves are seen in some patients during the procedure, but it is unclear whether these findings are related to myocardial ischemia (McCall 1997; Zvara et al. 1997). An alternative mechanism may be a direct effect of central nervous system stimulation on cardiac repolarization (Welch and Drop 1989). No corresponding increase in levels of cardiac enzymes has been found to accompany these electrocardiographic changes (Braasch and Demaso 1980). In a study of patients receiving ECT, Messina et al. (1992) obtained echocardiograms during and after ECT treatments and found transient regional wall motion abnormalities more often in patients with ST-T wave changes on electrocardiograms (ECGs), suggesting a period of demand myocardial ischemia. The clinical importance of these findings remains to be evaluated.

The effects of age on the cardiovascular response to ECT have been examined in only a few modern studies. Shettar et al. (1989) randomly assigned 19 patients (mean age 51 years; range 19–84 years) to ECT with pretreatment with glycopyrrolate or with placebo; the alternate pretreatment drug was used for the subsequent ECT treatment (i.e., each patient served as his or her own control). For both types of pretreatment, there was no correlation between age and length of poststimulus asystole. In two controlled studies of mixed-age samples that included elderly patients (Prudic et al. 1987; Webb et al. 1990), no relationship was found between age and ECT-induced changes in heart rate, blood pressure, or rate-pressure product. In a study of relatively younger patients (mean age 43 years; range 20–64 years), Huang et al. (1989) noted a significant inverse correlation between age and increases in blood pressure and rate-pressure product.

Although these results suggest that age, per se, is not associated with the extent of the cardiovascular response to ECT, these findings must be interpreted cautiously. Some of the subjects in these studies (especially those who were older) were also receiving antihypertensive drug therapy that may have attenuated their cardiovascular response to the treatments, and other clinical observations suggest that at least some elderly patients with cardiovascular disease may be at risk for marked increases in pulse and blood pressure during ECT (Applegate 1997; Zielinski et al. 1993; see also "Cardiovascular Side Effects" later in this chapter).

Mechanisms of Action of ECT

Despite considerable research into the neurobiology of ECT, its mechanism of action remains a mystery. ECT produces both acute and long-standing changes in brain chemistry, endocrinology, physiology, and neurogenesis and neuroplasticity (Holtzmann et al. 2007; Wahlund and von Rosen 2003). Current hypotheses of the mechanism of action of ECT focus on the *anticonvulsant effects* of the treatment (Sackeim 1999) or the extent and efficiency of *seizure generalization* throughout the brain and the resultant neurobiological effects in relevant brain regions (particularly prefrontal and diencephalic) (Abrams 2002b). It remains unclear, however, whether any of these neurobiological changes account for the clinical effects of ECT or whether they merely represent epiphenomena. Furthermore, the broad therapeutic spectrum of ECT (i.e., in addition to its antidepressant properties, ECT also exhibits antimanic, antipsychotic, anticonvulsant, and anticatatonic effects) would seem to make it unlikely that a single mechanism of action will explain all of these effects.

Technique of ECT

Pretreatment Evaluation

When a patient is referred for ECT, a formal pretreatment evaluation is carried out by a practitioner credentialed in ECT to 1) determine if ECT is indicated, 2) establish baseline measures of efficacy and cognitive side effects, 3) identify and treat any general medical conditions that may increase the risk of adverse effects (performed in conjunction with an anesthesia provider), 4) determine the setting (inpatient or outpatient) in which the treatments should be administered, 5) initiate the process of informed consent, and 6) prepare the patient and family or significant other for the procedure (American Psychiatric Association 2001; Coffey 1998).

The *indications for ECT* (discussed in "Diagnostic Indications and Efficacy" earlier in this chapter) are confirmed through

a thorough neuropsychiatric history and examination (see Chapter 4, "Neuropsychiatric Assessment"). The patient's response to previous therapies, including ECT, should be thoroughly documented. Handedness should also be assessed because of its relevance to nondominant unilateral electrode placement (Kellner et al. 1997). Because the hand used for writing is a fallible indicator, patients should be asked which hand they use to throw a ball, cut with a knife, and so on (American Psychiatric Association 2001).

The neuropsychiatric history and examination also provide an opportunity to obtain *objective baseline data* essential for assessing the outcome of the course of ECT. A variety of measures of symptom severity are available for each diagnostic indication (e.g., the Montgomery-Åsberg Depression Rating Scale or the Hamilton Rating Scale for Depression for depression, the Brief Psychiatric Rating Scale for psychosis), and these can be used as markers of efficacy when administered regularly over the treatment course. Both clinician- and patient-rated instruments should be considered, given the potential dissociation between observer- and self-rated symptom severity. Measurement of baseline cognitive function (in particular, attention and memory) is essential to assess any cognitive side effects from the course of ECT. The ideal cognitive measure would be brief, inexpensive, simple to administer, and sensitive to change in both verbal and nonverbal spheres, and it would have multiple forms (to avoid practice effects). Although several instruments are available, none is ideal, and options range from a bedside mental status examination, to a brief instrument such as the Mini-Mental State Examination, to formal neuropsychological testing.

A general medical history and examination are also performed to identify any active *general medical problems*, with a focus on the brain, the cardiovascular system, the musculoskeletal system, the dentition, and the upper gastrointestinal tract. Any personal or family history of problems with anesthesia should also be noted. A limited laboratory evaluation (serum potassium, ECG) is sufficient for most patients, with other studies ordered only as clinically indicated. Consultation with anesthesia specialists is important because the provision of general anesthesia is associated with some, albeit small, medical risk. Indeed, an anesthesiologist experienced in ECT may also serve as the "general medical" consultant and can greatly facilitate the evaluation of patients with serious systemic illness. Although ECT has no "absolute" contraindications, serious disease of the brain (e.g., aneurysm, tumor), heart (ischemia or failure), or other systems (e.g., pheochromocytoma, retinal detachment) will require stabilization and optimal treatment and may necessitate additional consultation with other specialists, such as cardiologists, neurologists, or neurosurgeons.

Adjustments may also be required in some of the patient's *general medications*. Theophylline levels should be monitored closely or discontinued if possible, because high blood levels during ECT have been associated with status epilepticus (Fink and Sackeim 1998). Metrifonate and echothiophate are organophosphate medications that irreversibly inhibit cholinesterase and pseudocholinesterase, and may cause prolonged apnea when combined with succinylcholine and should not be given. In theory, the duration of succinylcholine muscle relaxation could be increased by cholinesterase inhibitors such as rivastigmine, donepezil, tacrine, and galantamine, which are used in patients with Alzheimer's disease (see Chapter 16, "Alzheimer's Disease and the Frontotemporal Dementia Syndromes"). However, case reports (Zink et al. 2002) and growing clinical experience suggest that acetylcholinesterase inhibitors may be continued safely during ECT. Otherwise, patients should take any required medications as scheduled.

Typically, *psychotropic medications* are stopped before ECT, with the exception of antipsychotics and possibly antidepressants (Farah et al. 1995). Lithium taken around the time of ECT has been linked to an increased occurrence of delirium and prolonged seizures (Weiner et al. 1980). For most patients, lithium can be discontinued or at least held for 1 day before ECT, with serum lithium levels kept as low as clinically feasible (Dolenc and Rasmussen 2005; Kellner et al. 1991a). Complete discontinuation of lithium may not be advisable for other patients with severe and recurrent mood disorder, particularly when ECT is used as a continuation/maintenance treatment. Thus, the decision to use lithium concurrent with ECT must be made on a case-by-case basis. Benzodiazepine use should be minimized or stopped, whenever possible, before ECT. Benzodiazepines may impair the induction or spread of the therapeutic seizure, thereby potentially decreasing treatment response (Kellner 1997b; Pettinati et al. 1986). The use of these agents by elderly patients may also theoretically increase their susceptibility to cognitive side effects from ECT. When necessary, the use of the lowest feasible doses of agents with relatively short half-lives and no active metabolites (e.g., lorazepam, oxazepam) has been recommended (American Psychiatric Association 2001). Similarly, anticonvulsant medications prescribed for psychiatric indications (e.g., mood stabilizers) should usually be tapered and discontinued before ECT, to avoid problems with seizure induction or effectiveness. Antidepressant medications are usually stopped to avoid cumulative cardiac and central nervous system side effects, although this practice is now being reconsidered, particularly with the newer agents (American Psychiatric Association 2001). Studies have reported conflicting findings on whether the addition of an antidepressant medication enhances the efficacy of ECT (Lauritzen et al. 1996; Mayur et al. 2000; Sackeim et al. 2009; Seager and Bird 1962).

Initiating the *informed consent process* is another essential element of the pre-ECT workup. Written informed consent for ECT is required from any patient with the capacity to give voluntary consent, and the consent form and process must be in compliance with all applicable laws, statutes, and standards. Patients who lack such a capacity may require the judicial appointment of a legal guardian to provide the consent. The American Psychiatric Association provides a pertinent sample of an informed consent document for ECT and discusses in detail the appropriate process for obtaining such consent (American Psychiatric Association 2001).

The complexities of voluntary consent for an elderly patient with a neuropsychiatric disorder are discussed in Chapter 14, "Ethical and Legal Issues." With the increased prevalence of cognitive impairment in elderly patients, competency to consent becomes a major issue, and the education of both patient and family becomes essential. This is also a time in the patient's life cycle when children are becoming increasingly responsible for their parents, and the patient's children should be involved in the consent process whenever possible. Of particular relevance to ECT, compared with younger patients, those over age 65 appear to be less aware that they can refuse ECT (Malcolm 1989).

Finally, the pre-ECT evaluation affords the clinician an opportunity to establish important interpersonal relationships with the patient and family. These relationships can be therapeutic and enhance patient satisfaction, as well as provide personal reward to the clinician.

ECT Procedure

In the United States, ECT is commonly given as a series of single treatments on alternate mornings, typically at a frequency of three times a week (on Monday, Wednesday, and Friday). Many patients receive the treatments on an outpatient basis, as long as certain precautions are taken (Fink et al. 1996). First, the patient's psychiatric illness must allow for safe management outside the hospital. Clearly, acute suicide risk or agitated psychosis often requires hospitalization. Second, the patient's general medical status should be stable enough for safe outpatient management. In addition, elderly persons are at risk for falling, and ECT may temporarily exacerbate this risk (Rao et al. 2008). Third, strong social support is required, because family members or others must transport the patient to and from the treatment facility, ensure that the patient takes nothing by mouth for at least 8 hours before a treatment session, and provide supervision between treatments (with particular attention paid to ensuring that the patient refrains from driving and making important financial or personal decisions while experiencing cognitive side effects) (Fink 1994). For some patients, it is helpful to administer the first (or several initial) ECT treatment(s) on an inpatient basis and then switch to outpatient treatments once it has been established that outpatient treatments can be administered safely and comfortably.

The treatment team consists of a psychiatrist, an anesthesiologist, and specially trained nursing personnel. ECT is typically given in either a special treatment suite or the recovery area of an operating room suite. Patients have been previously evaluated for treatment indications and coexisting general medical conditions by the ECT practitioner and anesthesia provider, appropriate treatment of these conditions has been implemented, and the consent process has been initiated. Patients should have nothing to eat or drink for at least 8 hours before treatment. The standard technique requires the establishment of a patent intravenous line. Electrodes for stimulation and for monitoring the seizure are applied according to appropriate technique (Kellner et al. 1997). Before anesthesia induction, a verbal "time-out" procedure should be conducted to confirm the patient's identity and details of the procedure (e.g., stimulus electrode placement, medication dosages). Administration of the anesthesia and maintenance of the patient's airway are under the direction of the anesthesia provider. The medication sequence includes anticholinergic premedication (glycopyrrolate or atropine) to prevent vagal-mediated cardiac slowing (if indicated), followed by an anesthetic (usually methohexital) and then succinylcholine for muscle relaxation. Throughout the procedure, the patient is ventilated with 100% oxygen by mask, and heart rate, ECG, blood pressure, and blood oxygen saturation are monitored.

Once the patient is asleep and thoroughly relaxed, a specially designed bite block is inserted into the patient's mouth, to protect the tongue and teeth from injury during jaw clenching as the electrical stimulus is applied (caused by direct electrical stimulation of the temporalis muscles). A predetermined electrical stimulus (see "Electrical Stimulus Mode, Waveform, and Dosing" later in this chapter) is delivered across electrodes placed on the patient's properly prepared scalp. Typically, a generalized seizure ensues and lasts from 30 to 60 seconds. The seizure is monitored by electroencephalography and by observation of the motor manifestations of the seizure, typically at the right ankle where a blood pressure cuff was inflated above systolic pressure immediately before administration of succinylcholine (the cuff is deflated once the seizure has ended). Ventilatory support is continued until the patient emerges from the anesthesia, and further recovery is provided in an environment with as little stimulation as possible. The entire procedure takes ~20 minutes, and patients are often able to have breakfast within 1 hour of the time of treatment. They are discharged shortly thereafter.

A typical acute course of ECT consists of 6 to 12 treatments, although occasionally patients may require fewer or more treatments to achieve full response. The treatment schedule is

often modified in elderly patients to lessen cognitive side effects, with treatments given once or twice per week rather than three times per week (American Psychiatric Association 2001; Freeman 1995; Kellner et al. 1992; Lerer et al. 1995). ECT is stopped when maximal clinical improvement is thought to have been achieved or when further improvement is not noted between treatments. Special attention is then given to continuation/maintenance treatment with either medication or ECT.

Anesthesia Considerations

Brief, light general anesthesia is used during ECT to render the patient unconscious during (and thus amnesic for) the procedure. Methohexital is the agent of choice because it has a rapid onset and a brief duration of action, it induces minimal postanesthesia confusion, and it is relatively inexpensive. Methohexital also appears to have a lesser anticonvulsant effect than thiopental or propofol (Bergsholm and Swartz 1996), which benefits seizure induction and spread. Still, because methohexital is an anticonvulsant and because the seizure threshold is often increased in elderly patients (see the following section), the lowest effective anesthetic dose is desirable. Because methohexital dosing is based on lean body mass, the required methohexital dosage in many elderly patients may be less than 1 mg/kg total body weight (Fragen and Avram 1990).

Etomidate is a reasonable alternative to methohexital, especially in cases of severe cardiovascular disease, but it is more expensive and is associated with pain on infusion, longer cognitive recovery time, and short-term adrenocortical suppression. Ketamine may be considered in patients with high seizure thresholds because of its proconvulsant properties, although it is somewhat slower acting and has a longer duration of action. Propofol, another alternative anesthetic agent, is well tolerated but has anticonvulsant properties and may be associated with shorter seizures (American Psychiatric Association 2001).

The preferred neuromuscular blocking agent for ECT is succinylcholine, primarily because it has rapid onset and a brief duration of action. The use of succinylcholine may require special consideration in elderly patients. Succinylcholine indirectly stimulates muscarinic cholinergic receptors in the sinus node, causing a prolonged depolarization followed by a depolarized state, which is resistant to further stimulation. The initial depolarization may contribute to bradycardia, especially if serial doses are required. This effect may be pronounced in patients receiving beta-blockers and in those with evidence of preexisting conduction delay, both frequently the case among elderly patients. Pretreatment with anticholinergics, such as atropine or glycopyrrolate, will block this bradycardic effect. Succinylcholine may also trigger life-threatening hyperkalemia in patients who have muscle wasting, a potential concern in some elderly patients who have severe inanition from melancholia or in those who have been relatively immobilized (e.g., from stroke or neuromuscular disorders). Use of a nondepolarizing muscle relaxant should be considered in these patients.

Intragastric pressure also increases with the use of succinylcholine, related to abdominal skeletal muscle fasciculation, and this may increase the risk of gastric reflux and aspiration. Certain groups of elderly patients (e.g., those with hiatal hernia, gastroparesis, or morbid obesity) are at risk for substantial gastroesophageal reflux during the procedure, with subsequent risk for aspiration pneumonitis (Zibrak et al. 1988). Smokers are particularly prone to morbidity from aspiration (Lichtor 1990). In these patients, additional strategies beyond withholding oral food and fluids before a session may be considered to decrease gastric acidity (e.g., premedication with histamine H_2 receptor antagonists or sodium citrate) and volume (e.g., premedication with metoclopramide) (Lichtor 1990).

Electrical Stimulus Mode, Waveform, and Dosing

The ECT stimulus should be delivered with a contemporary bidirectional, constant-current, brief-pulse device. A constant current provides for stable delivery of the ECT stimulus over a range of patient impedances. The brief-pulse waveform, with a pulse width of 0.5–2 milliseconds, is a more efficient and physiological stimulus for inducing seizures, relative to the sine wave current (phase period ~8.33 milliseconds) employed by early-model ECT devices, and therefore is associated with decidedly fewer cognitive side effects without loss of efficacy. The two major ECT devices currently produced in the United States—spECTrum by MECTA (Figure 10–1) and Thymatron System IV by Somatics (Figure 10–2)—are designed to deliver constant-current, brief-pulse stimulation, the use of which is strongly recommended by numerous professional organizations.

The *ECT stimulus intensity*, or stimulus dosage, should be sufficiently above the patient's seizure threshold to induce an effective seizure. Older patients require higher ECT stimulus intensities to elicit such seizures than do younger patients, because seizure threshold (the amount of electricity required to elicit a seizure) increases with age, as well as with gender (higher in males) and stimulus electrode placement (higher in bitemporal than in unilateral nondominant) (Coffey et al. 1995a; Sackeim et al. 1991). This age effect is believed to be the result of a decrease in the excitability of the brain but may also be partially due to increases in skull thickness (electrical resistance) with aging. It should be noted that the efficiency of seizure induction with the brief-pulse stimulus may vary as a function of the parameters (i.e., pulse width, frequency, duration, and current) of the stimulus set. For a given stimulus charge, those stimuli with shorter pulse widths and longer

FIGURE 10–1. Frontal view of the spECTrum 5000Q ECT device by MECTA.

FIGURE 10–2. Frontal view of the Thymatron System IV ECT device by Somatics.

train durations are more efficient at seizure induction (i.e., are associated with a lower seizure threshold) than those with longer pulse widths. We recommend using parameter sets that employ pulse widths of 0.5–1 milliseconds. Research is under way to determine the clinical effects of even shorter pulse widths (so-called ultra-brief-pulse ECT) (Sackeim et al. 2008).

The precise stimulus dosage for optimal ECT has yet to be determined. Data in adult mixed-age samples suggest an interaction of stimulus dosage, stimulus parameters, electrode placement, and clinical efficacy. Bitemporal ECT is clinically effective at a stimulus dosage of 1.5–2.5 times seizure threshold (so-called moderate-dose ECT), but optimal unilateral nondominant ECT may require a stimulus dosage of ~4–6 times seizure threshold (so-called high-dose ECT) to match the efficacy of bitemporal ECT (McCall et al. 2000; Sackeim et al. 1993, 2000, 2008). In a study of 39 elderly inpatients with major depression, Stoppe et al. (2006) found similar rates of remission in those randomly assigned to high-dose unilateral nondominant ECT (88% remission) and in those who received moderate-dose bitemporal ECT (68% response rate). Thus, a critical factor in the efficacy of ECT appears to be the stimulus dosage relative to the patient's seizure threshold, adjusted for the effects of stimulus electrode placement.

The ECT specialist may use a number of options to determine the proper stimulus dosage for an individual patient (Coffey 2008). One approach is to employ a stimulus titration procedure at the first treatment to estimate initial seizure threshold and then adjust stimulus dosage upward accordingly at subsequent treatments (Coffey et al. 1995a). However, with this maneuver the first treatment can be assumed to be less than optimally effective if unilateral nondominant electrode placement is employed (because the seizure will be elicited by a "barely suprathreshold" stimulus dosage known to be subtherapeutic), and it carries a small risk of bradycardia and asystole associated with stimulation of the parasympathetic nervous system. These problems are obviated by an alternate "fixed-dose" method wherein the initial stimulus dose is set at 75%–100% of the maximum output (~576 mC) of contemporary U.S. ECT devices for right unilateral electrode placement or at approximately half the patient's age (in per-

centage of device output) for bilateral electrode placement (Petrides and Fink 1996). That dosage could then be titrated upward or downward at subsequent ECT treatments, using some established physiological "benchmark" of an "effective" seizure, such as peak heart rate or quantitative EEG metrics (e.g., percentage adequacy, postictal suppression index).

Seizure threshold increases during ECT (the well-known anticonvulsant effect), at times necessitating increases in stimulus dose during the course of therapy (Coffey et al. 1990, 1995b; Kellner et al. 1997). This effect does not appear to be more pronounced in elderly patients, but because this population has a higher initial seizure threshold, some older patients may eventually require stimulus intensities during their course of treatment that exceed the maximal dosage of the ECT device (Krystal et al. 2000; Lisanby et al. 1996). In this setting, successful seizure induction may be accomplished with the use of more efficient stimulus parameter sets (as discussed above) or by a switch to a proconvulsant anesthetic agent such as ketamine.

Stimulus Electrode Placement

ECT is generally administered through stimulus electrodes placed bitemporally, bifrontally, or in a unilateral nondominant position (the right side for most patients). The choice of stimulus electrode placement is complex. Studies in mixed-age samples of adults suggest that right unilateral ECT has fewer cognitive side effects, but as noted above, unless stimulus dosage and electrode application are carefully prescribed and certain medications restricted, treatment efficacy may be limited with this placement. Bilateral (bitemporal) electrode placement may be more reliably effective but may be associated with greater cognitive side effects (for a review, see Abrams 2002b).

Few studies have addressed the issue of electrode placement specifically in elderly patients. In a meta-analysis of the early literature, Pettinati et al. (1986) found a trend for improved efficacy in elderly patients receiving bilateral treatment. In one of the few controlled studies, Fraser and Glass (1980) assigned 29 elderly patients with depression to either unilateral or bilateral ECT two times a week. Stimulus-dosing strategies were unclear. No group differences were observed in terms of therapeutic response or memory performance after ECT, but those subjects randomly assigned to bilateral electrode placement required more time to become reoriented after the fifth ECT treatment. More recently, Stoppe et al. (2006) randomly assigned 39 elderly inpatients to unilateral or bitemporal high-dose ECT and found similar remission rates (88% and 68%, respectively) but fewer cognitive side effects with unilateral ECT. No studies have examined whether the effects of cerebral disease or age-related structural brain changes modify the therapeutic or adverse effects of unilateral versus bilateral ECT in elderly patients.

Thus, limited data exist to guide the choice of ECT electrode placement in elderly patients with neuropsychiatric illness. A reasonable approach in most elderly patients is to begin with unilateral nondominant ECT at a sufficiently high stimulus dosage; if minimal or no response is seen by the fifth or sixth treatment, then switch to bilateral ECT at moderate stimulus dosage. Because bilateral ECT may be associated with a statistically greater likelihood of response, it may be considered the treatment of choice in patients in urgent need of care. If intolerable cognitive side effects develop with bilateral ECT, the treatment may be changed to unilateral ECT once the affective disorder has begun to respond (other techniques for lessening cognitive side effects are discussed later in this chapter in "Adverse Effects of ECT and Their Management"). Finally, atypical electrode placements (e.g., left unilateral, right frontotemporal–left frontal, or bifrontal) may be clinically useful in some elderly patients (Bailine et al. 2000; Kellner 1997a, 2000; Little et al. 2004).

Seizure Monitoring

The ECT seizure should be monitored to confirm that a seizure has occurred and to determine when it has ended (Kellner et al. 1997; Weiner and Krystal 1993). The seizure may be monitored indirectly by observation of the motor response (convulsion) of a "cuffed" extremity, but additional monitoring with ictal electroencephalogram is now considered the standard of care. The ictal electroencephalogram has been studied using sophisticated computer analysis to determine whether seizure "potency" (and treatment efficacy) may be predicted by various indices such as amplitude, regularity, or coherence (Krystal et al. 1995, 1996; Weiner and Krystal 1993). Newer ECT devices now provide quantitative estimates of various ictal EEG indices, but their routine clinical utility is limited at present by their sensitivity to EEG artifacts, variation in EEG lead placement, and interindividual and intraindividual variation in the ictal electroencephalogram (Krystal et al. 1998).

Treatment Frequency and Number

A course of 6 to 12 treatments is usually required for treatment of an acute episode of major or bipolar depression, although fewer or more treatments are sometimes needed. Patients with schizophrenia may require a larger number of treatments. In the United States, the treatments are typically given thrice weekly, but in Europe a twice-weekly schedule is often employed.

The treatments are continued until the patient has reached a maximum level of response, at which point their frequency is tapered in preparation for continuation treatment. As discussed above, the ECT treatment technique should be modified (e.g., switch stimulus electrode placement, increase stimulus dosage) if no improvement is seen by the sixth treatment.

Alternative treatments should be considered if no response is observed by 8 to 10 treatments, although in some cases a longer series of treatments will be necessary.

Continuation/Maintenance Treatment

Because mood disorders are increasingly recognized as chronic, relapsing conditions, successful acute treatment should be followed by some form of continuation or maintenance treatment to prevent relapse or recurrence of the mood episode (see Chapter 19, "Mood Disorders"). Studies in mixed-age samples of adults with major depressive disorder have found 6-month relapse rates as high as 50% for patients initially responsive to antidepressants who were subsequently withdrawn from the medications (Prien and Kupfer 1986). Relapse rates following successful pharmacotherapy for major depression are substantially reduced by continuation of antidepressant medication at full dosage (Frank et al. 1990). Similarly high rates of relapse have been noted in adults with depression following ECT response when no form of continuation therapy was given (Jarvie 1954). The risk of relapse after successful acute ECT may be particularly high (especially in the first 4 months following ECT) in patients with major depression who were resistant to medication or who displayed psychotic symptoms during their index episode of illness (Grunhaus et al. 1995; Sackeim et al. 1993).

For continuation treatment in patients with *major depression* who are successfully treated with ECT acutely, there are two options: combination pharmacotherapy or continuation ECT. Controlled data suggest that continuation pharmacotherapy with nortriptyline and lithium (6-month relapse rate of 39%) is superior to nortriptyline alone (6-month relapse rate of 60%), which is in turn superior to placebo (6-month relapse rate of 84%), in preventing relapse of major depression in adults who have responded to an acute course of ECT (Sackeim et al. 2001). Continuation treatment with ECT is another option for continuation/maintenance treatment following successful acute ECT treatment, particularly in patients who have psychotic depression or those who were resistant to medication during the index episode (Fink 2007). Controlled data in a mixed-age sample of adults with major depression indicated that continuation ECT is comparable to continuation pharmacotherapy (nortriptyline and lithium) following a successful acute course of brief-pulse bitemporal ECT given at 1.5 times seizure threshold (6-month relapse rates of 37% and 32%, respectively) (Kellner et al. 2006). These data extend clinical reports of successful continuation ECT in elderly patients with major depression (Clark et al. 1989; Dubin et al. 1992; Loo et al. 1991; Monroe 1991; Thienhaus et al. 1990).

Continuation/maintenance ECT typically involves single treatments administered on an outpatient basis, initially at weekly intervals and then gradually reduced in frequency to every 4–8 weeks, as the patient's symptoms allow. The increased interval between treatments results in fewer cognitive side effects than during an acute course of ECT, and this has led to the suggestion that bilateral electrode placement may be preferred for continuation/maintenance ECT. The logistical factors in outpatient ECT are defined in the report by the Task Force on Ambulatory ECT of the Association for Convulsive Therapy (Fink et al. 1996).

No controlled data have been reported to inform the choice of whether to use pharmacotherapy or ECT for continuation treatment following successful ECT in patients with major depression. In clinical practice many clinicians use the rule "what got you well is what will keep you well," which would lead to a recommendation for ECT provided that it was reasonably well tolerated. For at least some patients, however, the logistical issues involved in months or years of continuation ECT are simply not manageable, and they prefer to take their chances with medication.

As noted earlier in this chapter, patients with *bipolar disorder* may be successfully treated with ECT for acute mania or bipolar depression. Following such acute treatment, we generally recommend at least 9–12 months of maintenance treatment with ECT, although there are no controlled data on this issue. During this maintenance ECT course, we continue to withhold mood-stabilizing agents (e.g., lithium, anticonvulsants) to avoid their potential complications (discussed in "Pretreatment Evaluation" earlier in this chapter). On the other hand, some clinicians are concerned that breakthrough mood syndromes may occur as the frequency of the maintenance ECT treatments is decreased, and thus they prefer to administer a mood stabilizer between treatments, holding the dose a few days before a scheduled ECT treatment to avoid potential complications. Most patients with bipolar disorder require lifetime maintenance treatment with at least a mood stabilizer (e.g., lithium, anticonvulsants). Some clinical literature and our own experience suggest that ECT may serve this role (alone or in combination with psychotropic medication variously prescribed) in some patients who tolerate the procedure and related logistical issues well.

Following successful treatment with an acute course of ECT, most patients with *schizophrenia* receive maintenance treatment with antipsychotic medication (occasionally in combination with other psychotropic medications). The potential role of maintenance ECT in such patients has not been studied.

Adverse Effects of ECT and Their Management

The safety of ECT compares favorably with that of any treatment requiring general anesthesia. The mortality is variously reported as approximating 1 death per 80,000 treatments (the same as for general anesthesia for minor surgery) and may actually be de-

creasing with improved management of underlying general medical illnesses. To put these data into perspective, Abrams (2002b) noted that ECT is 10 times safer than childbirth.

Kroessler and Fogel (1993) compared the mortality during long-term follow-up of 65 depressed patients ages 80 and older who had been treated with ECT or antidepressant medication. Although the 2-year survival rate was 54% in the group treated with ECT and 90% in the group treated with medication, this group difference was probably related to more severe depression and physical illness in the patients who received ECT. The course of ECT itself was remarkably well tolerated by these elderly patients, with a median interval between ECT and time of death of 20 months. The authors called for further attention to general medical comorbidity as a prognostic factor in future outcome studies of geriatric depression. Abrams (2002a) noted that the estimated mortality rate among community-dwelling elderly patients (~0.26% per each 3 weeks) was an order of magnitude higher than that observed after a 3-week course of eight ECT treatments in elderly patients (~0.016%). As noted earlier in "Medical Physiology of ECT," the major physiological impact of ECT is on the heart, vasculature, and brain.

Cardiovascular Side Effects

A proportion of elderly patients referred for ECT have serious preexisting cardiovascular disease. Common cardiac conditions, such as hypertension, ischemic heart disease, atrial and ventricular arrhythmia, aneurysm, and conduction system disease, require evaluation and optimized treatment before ECT to minimize any adverse effects from the hemodynamic events that occur during ECT (Priebe 2000).

Uncontrolled retrospective studies comparing the cardiovascular complication rate of ECT in older and younger patients have found an increase in transient and treatable complications in elderly patients. In a nonblinded retrospective chart review of 293 patients, Alexopoulos et al. (1984) found cardiovascular complications in 9% of the patients ages 65 and older, compared with 1% of the patients under age 65. Cardiac ischemia, arrhythmia, hypertension, and congestive heart failure were the most common complications, although the vast majority of complications were not clearly temporally related to ECT and did not prevent the completion of treatment. Burke et al. (1987) conducted a similar retrospective chart review of 136 subjects, 30% of whom were ages 60 and older. Sine wave bilateral ECT was used in 85% of cases. These investigators found a cardiorespiratory complication rate of 15% in patients ages 60 and older, compared with 3% in those under age 60. Complications were correlated with the number of cardiovascular medications the patient was receiving, with more medication presumably indicating those patients with more cardiovascular illness. These complications did not affect treatment response. In a chart review of 81 elderly patients, Cattan et al. (1990) found a 36% cardiovascular complication rate with ECT in patients over age 80, compared with 12% in younger geriatric patients. As would be expected, the older patients had more general medical diagnoses and were receiving more cardiovascular medication than were the younger patients.

Two controlled studies of ECT in a total of 66 high-risk patients with cardiovascular disease have demonstrated the safety of ECT in elderly individuals. Zielinsky et al. (1993) compared the rate of cardiac complications in a group of 40 depressed patients (mean age 68.9 years; range 54–84 years) with serious preexisting cardiac disease (left ventricular impairment, conduction delay, and ventricular arrhythmias) with the rate of such complications in a group of 40 depressed patients (mean age 68.3 years; range 55–83 years) without cardiac disease. Not surprisingly, the group with preexisting cardiac disease had more complications. Most of the complications were transient (e.g., brief arrhythmias or increases in ectopy), however, and 38 of the 40 patients with cardiac disease were able to complete their course of ECT. Of note, this group of depressed patients with cardiac disease had even more difficulty with adverse cardiac effects from prior trials of tricyclic antidepressants; 11 of the 21 patients previously treated with tricyclic antidepressants had been forced to stop tricyclic treatment because of cardiovascular complications. Rice et al. (1994) used a case-control design to compare two groups of patients over age 50 receiving ECT. One group consisted of 26 patients at increased risk for cardiac complications, and 27 patients at standard risk made up the other group. Compared with the patients at standard risk for cardiac complications, patients in the high-risk group were older, had received more medical consultations before ECT, and experienced more minor medical complications from ECT. However, the two groups did not differ in terms of frequency of major medical complications, and no patients died or experienced permanent cardiac morbidity from ECT.

The data just reviewed suggest that ECT is a low-risk procedure, even for elderly patients (Applegate 1997). It is rare for ECT to be associated with severe cardiovascular complications, such as acute myocardial infarction, stroke, cardiovascular collapse, ventricular arrhythmia, or ruptured cerebral or aortic aneurysm. Still, prospective studies, carefully controlled for pretreatment severity of cardiovascular and other medical disease, are needed to evaluate the effects of age on cardiovascular complications of ECT.

Increasingly sophisticated general medical management during ECT helps to decrease the cardiovascular risk of treatment in elderly patients (Applegate 1997). The primary areas of concern are bradycardia, tachycardia, hypertension, and ventricular arrhythmia. Anticholinergic premedications (at-

ropine and glycopyrrolate) may be used to prevent *vagally induced bradycardia*, but in elderly patients the use of these medications may be more complicated by confusion, tachycardia, constipation, and urinary retention. The method of serial electrical stimulations to determine a patient's seizure threshold (described earlier) may involve administration of subconvulsive stimuli, which may produce a vagal surge unaccompanied by the sympathetic outflow associated with a seizure. The use of this method, as well as the presence of conduction delay on the ECG, suggests the need for premedication with an anticholinergic, particularly if the patient is also receiving a beta-blocker medication. Outside of these clinical scenarios, some practitioners reserve the use of anticholinergic premedication for patients who develop substantial bradyarrhythmias during ECT.

A related issue is the safety of ECT in a patient with a vagus nerve stimulator (see Chapter 11, "Brain Stimulation Therapies"), the effects of which might be thought to be problematic if they add to the vagal effects of ECT. Although experience is limited, the safe use of ECT in a patient with the vagus nerve stimulator has been reported (Husain et al. 2002).

Although *hypertension* and *tachycardia* (mediated by sympathetic activation) are common during ECT, they are well tolerated by most patients, including elderly individuals (Webb et al. 1990). Therefore, it is usually unnecessary to routinely blunt the cardiovascular response to ECT in elderly patients unless such changes are extreme or are clearly associated with evidence of cardiovascular compromise. These robust hemodynamic responses may be attenuated by short-acting intravenous beta-blockers, such as labetalol or esmolol, or by nitroglycerine preparations (Howie et al. 1990; Stoudemire et al. 1990). It should be kept in mind that beta-blockers have anticonvulsant effects, and their use during ECT may limit the intensity of the ECT seizure and, in turn, its therapeutic potency. In addition, the acute use of antihypertensive medication may lead to clinically significant hypotension in elderly patients during the recovery period. Finally, in patients receiving adrenergic blockers, anticholinergic premedication should be considered so as to prevent a disproportionate decrease of sympathetic tone below parasympathetic tone, with resultant bradycardia (Abrams 2002b).

Marked *posttreatment ventricular ectopy* (multifocal or several consecutive premature ventricular contractions) may be treated with lidocaine (1–1.5 m/kg body weight). Because of its anticonvulsant properties, lidocaine should be given after termination of the seizure (Drop and Welch 1989). Stoudemire et al. (1990) found that ventricular ectopy could also be reduced by pretreatment with labetalol. The presence of a properly functioning implanted cardiac pacemaker is not a concern with ECT, provided the usual electrical safety precautions are followed (Abrams 2002b).

Cerebral Side Effects

There is no evidence that ECT causes structural brain damage (Devanand et al. 1994; Weiner 1984). Carefully controlled prospective brain imaging studies in humans reveal no changes in brain structure for up to 6 months after a course of ECT (Coffey 1993; Coffey et al. 1991), and other studies using proton magnetic resonance spectroscopy find that ECT is not associated with a decrease in the *N*-acetylaspartate signal, a sign of cell atrophy (Ende et al. 2000; Pfleiderer et al. 2003). Neuropathological studies in elderly humans who received numerous lifetime ECT treatments reveal no evidence of ECT-related injury (Scalia et al. 2007). Neuropathological studies in animals, including cell counts in regions thought to be at risk, reveal no evidence of brain damage when the seizures are induced under conditions that approximate standard clinical practice (i.e., when the seizures are temporally spaced, relatively brief, and modified by oxygenation and muscle relaxation). Furthermore, studies of the pathophysiology of seizure-induced structural brain damage in animals indicate that the conditions necessary for injury do not apply to the modern practice of ECT (Weiner 1984). In this regard, a brain metabolic imaging study of elderly patients with depression found no evidence of brain perfusion abnormalities at 1 year following a successful course of ECT (Navarro et al. 2004).

The robust cardiovascular responses associated with the ECT seizure have raised a theoretical concern that they may precipitate cerebrovascular events. The incidence of *cerebrovascular complications* with ECT is exceedingly rare, however. We are aware of only one reported case of ischemic stroke after ECT that was confirmed by brain imaging (Bruce et al. 2006). ECT has been given successfully to patients with cerebral aneurysms, with close management of blood pressure elevation (Krystal and Coffey 1997). An intracerebral hemorrhage reported in a normotensive patient during ECT was probably related to cerebral amyloid angiopathy (Weisberg et al. 1991). We know of no other reported case of intracerebral hemorrhage with ECT.

Cognitive Side Effects

The cognitive side effects of ECT include acute postictal confusion, impaired retrograde and anterograde memory, and occasionally interictal delirium. The extent of these adverse effects is related to certain patient factors, such as increased age (see Gardner and O'Connor 2008 for a review), general medical disease burden, and preexisting cognitive impairment, and to ECT technique factors (sine wave stimulus waveform, bitemporal electrode placement, grossly suprathreshold stimulus dosage, increased number or frequency of treatments, poor oxygenation during the procedure, and certain concomitant medications, such as lithium and anticholin-

ergics) (see *The Journal of ECT,* Volume 24, No. 1, Special Issue: Cognitive Effects of ECT, 2008).

Acute Postictal Disorientation

Most patients experience mild disorientation immediately upon awakening during the post-ECT recovery process, which typically resolves within an hour or so (Calev et al. 1993). In a study focusing on elderly patients, Fraser and Glass (1978) measured time to recovery of full orientation in nine elderly patients with depression who received ECT in which electrode placement alternated (e.g., unilateral placement in one treatment followed by bilateral placement in the next treatment). When comparing these reorientation times with those reported in the literature for younger patients, the investigators observed that recovery in elderly patients took five times longer for unilateral treatment and nine times longer for bilateral treatment. Recovery time after bilateral ECT increased cumulatively over the course of ECT and with closer spacing of treatments. No such relationship was found for unilateral ECT. In a subsequent study of 29 elderly patients with depression randomly assigned to courses of either unilateral (n=13) or bilateral (n=16) sine wave ECT, Fraser and Glass (1980) found significantly longer reorientation times after the fifth ECT session among patients receiving bilateral treatments (32.8 minutes) than among those receiving unilateral treatments (9.5 minutes). In contrast to the group undergoing bilateral ECT, patients receiving unilateral ECT had a significant reduction in recovery time from the first to the last treatment.

In a study of subjective side effects during ECT, Devanand et al. (1995) found that older patients actually reported fewer severe cognitive symptoms (i.e., confusion/disorientation and amnesia) than did younger patients.

Agitated Delirium on Emergence From Anesthesia

Approximately 10% of patients receiving ECT experience an acute agitated delirium on emergence from anesthesia, characterized by restlessness, disorientation, combativeness, and poor response to commands. Age does not appear to be a risk for this complication (Devanand et al. 1989). This complication is usually managed effectively with supportive care, although occasionally treatment with intravenous benzodiazepines (e.g., midazolam, diazepam) or other sedatives (e.g., methohexital, propofol) may be required.

Interictal Delirium

In a small proportion of patients, ECT is associated with more prolonged disorientation and even frank interictal delirium. Most studies evaluating interictal delirium in elderly patients have used disorientation as a measure rather than the full DSM criteria for delirium. In a retrospective study involving 136 patients receiving mainly bilateral sine wave ECT, Burke et al. (1987) found disorientation (confusion severe enough to alter the treatment plan) in 18% of patients older than age 60, compared with 13% of younger patients. This incidence increased to 25% for patients over age 75. In a retrospective study in which mostly bilateral (waveform not specified) ECT was administered, Alexopoulos et al. (1984) found a somewhat greater incidence of confusion (disorientation to time, place, and person) in elderly patients (12.6%) than in younger patients (9.6%). Cattan et al. (1990) conducted a study involving primarily bilateral or combination bilateral-unilateral sine wave ECT and found a nonsignificant trend for more frequent severe disorientation (defined functionally by interference in ward activities) in elderly patients over age 80 (59%, n=39), compared with those patients 65–80 years old (45%, n=42).

In the study by Alexopoulos et al. (1984), elderly patients with a history of underlying brain disease were found to have higher levels of severe post-ECT confusion than were the young patients, suggesting that baseline cerebral impairment may increase the risk of adverse cognitive effects of ECT.

In several studies, subcortical brain disease has been implicated in the development of interictal delirium with ECT. We have found subcortical gray and white matter lesions to be more extensive in elderly patients who developed a prolonged interictal delirium during a course of ECT (Figiel et al. 1990). Still, the majority of these patients were able to continue ECT, with no decline in expected treatment response. All patients were free of delirium 1 week after ECT (Coffey et al. 1989; Figiel et al. 1990). The specificity of subcortical disease in producing delirium after ECT was further suggested by Martin et al. (1992), who found that patients with ischemic lesions of the caudate nucleus had a 92% incidence of delirium during ECT. Patients with a previous stroke in other brain regions had the same incidence of delirium as did a group of elderly depressed nonstroke control subjects receiving ECT (Martin et al. 1992). In a prospective study of seven consecutive patients with Parkinson's disease, Figiel et al. (1991) found a 100% incidence of interictal delirium during a course of ECT. The delirium lasted 7–21 days, longer than is typical, but 86% of patients recovered from depression.

In summary, although the duration and severity of acute post-ECT disorientation may increase with age, the majority of elderly patients appear to recover their orientation within 60 minutes of the treatment. In the small percentage of elderly patients who develop more prolonged confusion or frank delirium, underlying cerebral impairment may be contributory, especially dysfunction of the basal ganglia. Clearly, more research is needed in a larger number of elderly patients to characterize post-ECT confusion and to identify its risk factors, including the effects of preexisting cerebral impairment.

Amnesia

The depressive syndrome (as well as many other psychiatric syndromes) causes impairment in new learning. An acute course of contemporary brief-pulse ECT may improve this deficit as it improves the depression, but the treatment also causes a new deficit in memory such that newly learned information is rapidly forgotten. Explicit (especially autobiographical) memories are affected (implicit memory is spared), and both anterograde and retrograde deficits are seen, particularly for events that occurred closest to the time of treatment. This memory deficit is typically relatively mild and is presumed to be secondary to transient disruption of medial temporal lobe function. The anterograde amnesia typically resolves within a few weeks of ECT, whereas the retrograde deficit may resolve more gradually. Persistent and severe retrograde amnesia has been reported rarely following ECT (Sackeim 2000), but the interpretation and significance of such reports remain controversial (Abrams 2002a).

Given the large body of data on the amnestic effects of ECT, it is surprising that there has been relatively little controlled research on age as a risk factor (Abrams 1997; Calev et al. 1993; Fink 1979). Some (Fromholt et al. 1973; Heshe et al. 1978) but not all (d'Elia and Raotma 1977; Strömgren et al. 1976) early studies found that ECT-induced amnesia is worse in older patients. Zervas et al. (1993) examined age effects on memory in a study comparing twice-weekly and three-times-weekly brief-pulse bilateral ECT administered using contemporary techniques (given at "moderately suprathreshold" stimulus intensity). The sample consisted of 42 inpatients with a mean age (±SD) of 53.5±16.1 years; no patient was older than 65 years, however. Correlations were found between age and decrements in retrograde memory 1–3 days after the end of ECT but not at 1 month or 6 months posttreatment. Age was also correlated with decrements in verbal anterograde memory acutely and 1 month after ECT (but not 6 months after ECT) and with changes in figural anterograde memory acutely and 6 months after ECT. McElhiney et al. (1995) examined autobiographical memory in a mixed-age sample (mean age [±SD] 54±13.9 years) of 75 patients with depression randomly assigned with regard to electrode placement and stimulus intensity. Age was found to be a predictor of lower recall of autobiographical memories after ECT. In a follow-up report on this sample, the pre-ECT modified Mini-Mental State Examination score was predictive of the extent of retrograde autobiographical amnesia both 1 week and 2 months after ECT (Sobin et al. 1995). This study provided evidence in support of the conventional clinical wisdom that preexisting cognitive deficit is a risk factor for more severe ECT-induced amnesia.

Memory performance has been reported to improve with successful ECT in elderly patients with the pseudodementia of depression (Reynolds et al. 1987; Stoudemire et al. 1995). In the study by Fraser and Glass (1980) described earlier, all elderly patients showed impairment of memory function before ECT; during treatment, however, memory improved and was normal in all patients by 3 weeks after completion of the ECT course. No group differences were found on the basis of electrode placement.

Relatively little research has been done regarding the effects of age on subjective memory complaints after ECT (Prudic et al. 2000). As noted previously, Devanand et al. (1995) found that older patients actually reported fewer severe cognitive symptoms (i.e., confusion/disorientation and amnesia) than did younger patients.

In summary, controlled data appear to support the clinical wisdom that elderly patients are at greater risk for the cognitive side effects of ECT. More work is needed in a larger number of elderly patients (especially very old patients) to characterize the extent and severity of ECT-induced amnesia and to identify relevant risk factors, including the effects of preexisting cerebral impairment.

Managing Cognitive Side Effects During ECT

Recommendations for lessening ECT amnesia in elderly patients focus on risk factors related to the patients, as well as on aspects of the treatment technique. Patients should have their general medical health optimized as much as possible before commencing ECT, and concomitant medications with potential adverse effects on memory should be discontinued when possible. The ECT technique should employ proper anesthetic technique, a contemporary constant-current brief-pulse device, and careful consideration of the relative merits of unilateral versus bilateral stimulus electrode placement. If intolerable cognitive side effects develop, the frequency of treatments could be reduced from thrice to twice weekly (e.g., Monday and Friday). A variety of "memory-enhancing" pharmacological agents (e.g., indomethacin, piracetam, naloxone, choline, donepezil, and herbals) have been explored in animal models of ECT as well as in humans, but the data are insufficient to support routine clinical use at this time (Prakash et al. 2006; Prudic et al. 1998; Rao et al. 2002; Tang et al. 2002).

Side Effects in Other Organ Systems

Other organ systems that may be impaired in elderly patients need to be evaluated before ECT and include the lungs, bones, eyes, and teeth. Pulmonary status should be optimized before ECT. Patients with severe chronic obstructive pulmonary disease and carbon dioxide retention may require special ventilatory strategies during the treatment (Abrams 2002b). Pneumonia secondary to aspiration of gastric contents may occur rarely during ECT (Alexopoulos et al. 1984; Karlinsky and Shulman 1984).

Patients with osteoporosis, spinal disk disease, or spondylosis may require increased muscular relaxation during ECT. Such patients may require succinylcholine doses of at least 1–

1.5 mg/kg body weight, and they require careful attention to clinical evidence of adequate relaxation (e.g., loss of reflexes or tone, and disappearance of fasciculations) before delivery of the stimulus. Kellner et al. (1991b) reported the safe treatment of a patient with osteoporosis and cervical spondylosis with multiple subluxations of the cervical spine using succinylcholine doses of 1.3 mg/kg weight.

Because ECT produces a transient increase in intraocular pressure, patients with chronic open-angle glaucoma should receive their eyedrops before ECT. As noted earlier in "Technique of ECT," treatment with echothiophate, an irreversible cholinesterase inhibitor, should be stopped several days before ECT. Patients with acute closed-angle glaucoma or retinal detachment should be stabilized before ECT and watched closely by an ophthalmologist during an ECT course.

When a patient's teeth are loose, decayed, or asymmetrical, the risk of dental injury during ECT may be increased. A major portion of malpractice litigation with ECT is related to dental issues (Slawson 1985). A specially designed bite block must be inserted before delivery of the ECT stimulus. The tongue, cheeks, and lips must be kept clear of the clenching teeth. The bite block should be used even in edentulous patients. Occasionally, upper or lower dentures may be kept in place during the treatment to facilitate airway management. In patients with only a few remaining, and possibly loose, teeth, dental consultation or alternative bite block strategies (with the aim of shifting bite pressure to the molars) may be helpful (Welch 1993).

ECT in Elderly Patients With Neurological Disorders

Although mood disturbances are common in patients with neurological disorders, there are relatively few controlled data to inform their treatment (see chapters in Part IV, "Neuropsychiatric Syndromes and Disorders"). There are no controlled data on the safety and efficacy of ECT in depressed elderly patients with concomitant neurological disorders (Coffey et al. 2007; Van der Wurff et al. 2003); however, a substantial clinical experience suggests that ECT may be an important therapeutic option for many of these patients (Coffey et al. 2007; Evans et al. 2005; Krystal and Coffey 1997), particularly when there is an urgent need for rapid clinical improvement or when pharmacotherapy has been either ineffective or poorly tolerated. The safety of ECT in these patients depends critically on optimizing the treatment of the underlying neurological (and all other general medical) conditions and on modifying the technique of ECT where indicated to mitigate the procedure's physiological effects (e.g., increased intracranial pressure, increased blood pressure) (Coffey et al. 2007). In all such cases, a careful risk-benefit analysis should be conducted during the pre-ECT evaluation. In the following sections, we discuss some of the more common conditions in which ECT may be considered as a treatment option for elderly patients with a neurological disorder.

Dementia

As discussed in Chapter 16, "Alzheimer's Disease and the Frontotemporal Dementia Syndromes," depression is common in patients with dementia, and it has a critical impact on patients' survival and functional recovery. Treatment with antidepressant medications may help some but not all of these patients (see Chapter 19, "Mood Disorders").

A small clinical literature suggests that ECT may also be safe and effective for treating depression in patients with degenerative dementia, including those with Alzheimer's disease, vascular dementia, Friedreich's ataxia, and probable Lewy body dementia. In a literature review of 56 patients with dementia who received ECT for depression, Price and McAllister (1989) found the rate of response of depression to be 73%. ECT effectively treated depression in several subtypes of dementia, including senile dementia of the Alzheimer's type, multi-infarct dementia, and normal-pressure hydrocephalus, as well as the dementias of Parkinson's disease and Huntington's disease. Location of the stimulus electrodes was not specified in the majority of the cases reviewed. Nearly one-third of patients with dementia also had an improvement in cognition after ECT. Delirium was a relatively infrequent complication of ECT in these patients (overall occurrence of 21%), clearing by the time of discharge in all but 1 patient. Nelson and Rosenberg (1991) found that the ECT outcomes were similar in their 21 elderly patients with dementia and major depression, compared with a reference group of 84 elderly depressed patients without dementia. Rao and Lyketsos (2000) described their experience with 31 consecutive patients with dementia treated with ECT over a 5-year period at their institution. Approximately 68% of the sample was "clearly improved," and the most common adverse event was a transient delirium (seen in 49%). Rasmussen et al. (2003) described 7 patients with presumed Lewy body dementia who responded to ECT and tolerated the treatment well. Although these data are reassuring, prospective studies are needed to determine the efficacy and side effects of ECT in depressed patients with dementia.

To minimize cognitive side effects of ECT in patients with dementia, the ECT practitioner needs to pay special attention to issues of concomitant medications (including cholinesterase inhibitors, which may prolong the effect of succinylcholine as well as lower seizure threshold), electrode placement, and frequency of treatments (discussed earlier in "Technique of ECT"). Particular attention must be paid to issues of informed consent (see Chapter 14, "Ethical and Legal Issues").

Cerebrovascular Disease and Cerebral Aneurysm

As discussed in Chapter 25, "Cerebrovascular Disease," depression is common following stroke, and it has a critical impact on the patient's survival and functional recovery. Treatment with antidepressant medications may help some but not all such patients (see Chapter 19, "Mood Disorders").

Case reports and case series suggest that ECT may also be safe and effective for treating poststroke depression. In a retrospective chart review of 14 patients with poststroke depression (mean age 66 years) treated with ECT at Massachusetts General Hospital, Murray et al. (1986) found that 86% had marked improvement in depression after ECT. Apparently, no patient exhibited any worsening of neurological deficit, and although formal measures of cognitive status were not reported, 5 of the 6 patients with "cognitive impairment" before ECT showed lessening of this deficit after ECT. Currier et al. (1992) published retrospective data on 20 geriatric patients with poststroke depression treated with ECT at the same hospital, with predominantly nondominant unilateral electrode placement being used. A "marked or moderate response" to ECT was observed in 95% of the patients. No patient experienced any exacerbation of preexisting neurological deficits, but 3 patients exhibited "minor encephalopathic complications" (prolonged postictal confusion and amnesia) and 2 patients developed "severe interictal delirium requiring neuroleptics." Of note, 7 of their patients (37%) relapsed within a mean of 4 months after stopping ECT, despite ongoing maintenance drug therapy.

Elderly patients with no clinical history of stroke often have subcortical white matter hyperintensities on magnetic resonance images, which are believed to be evidence of ischemic cerebrovascular disease (see Chapter 19). Coffey et al. (1989) found a high rate (82%) of response to ECT in depressed patients with these magnetic resonance imaging findings, many of whom had been refractory to antidepressant drug therapy. In addition, the majority of the patients tolerated the course of ECT without major systemic or cognitive side effects. This positive outcome with ECT is especially notable given other data suggesting that subcortical ischemic disease may be associated with depressive illness that is resistant to treatment with antidepressant medications (Baldwin et al. 2004; Iosifescu et al. 2006).

The safety of ECT in a patient with cerebrovascular disease requires a thorough diagnostic assessment and optimal pre-ECT treatment of the cerebrovascular disease and any other general medical conditions. A diagnostic evaluation must clarify the precise etiology of the cerebrovascular event (arterial ischemic stroke vs. cerebral venous sinus occlusion vs. hemorrhagic stroke), and the treatment for that condition must be optimized. The clinician must also assess the potential effect of the underlying vascular disease on other organs impacted by ECT, notably the heart, and institute treatment when indicated. Before commencing ECT, it is preferable to wait at least several weeks if possible after the cerebral infarct to allow time for fragile cerebral vessels and tissue to heal, thereby reducing the theoretical risk of rupture from the increased cerebral blood flow. Occasionally, the ECT practitioner may employ antihypertensive medications during the ECT procedure to lessen the hemodynamic effects of the electrical stimulus and seizure.

The authors of several case and small series studies have reported on the safe and effective use of ECT in patients with intracranial aneurysm (including coil embolization) or various malformations, including arteriovenous malformations, venous angiomas, and cavernous hemangiomas (Okamura et al. 2006; Rasmussen and Flemming 2006; Zahedi et al. 2006). We are not aware of a report of patients with untreated cerebral aneurysm or malformation who experienced an intracranial hemorrhage with ECT. Nevertheless, we advise surgical correction of such lesions when indicated, before commencing ECT. If such surgery is not indicated, pharmacological attenuation of the hemodynamic responses during ECT should be considered.

Parkinson's Disease

As discussed in Chapter 24, "Parkinson's Disease and Movement Disorders," depression is common in patients with Parkinson's disease, and it has a critical impact on patients' survival and functional recovery. Treatment with antidepressant medications may help some but not all such patients (see Chapter 19, "Mood Disorders").

A small clinical literature suggests that ECT may be safe and effective for both the mood disorder and the motor disturbance associated with Parkinson's disease (reviewed by Kellner and Bernstein 1993). Interestingly, some patients experience improvement in motor symptoms but not improvement in mood, or vice versa (Kellner and Bernstein 1993).

A group of Swedish investigators (Andersen et al. 1987) performed the most methodologically rigorous trial of ECT in Parkinson's disease. In this double-blind, controlled, crossover design comparison of real ECT and sham ECT, 9 (82%) of 11 nondepressed elderly patients with the on-off phenomenon experienced substantial improvement in parkinsonian symptoms with ECT, with the improvement lasting 2–6 weeks. Sham ECT was ineffective. Nine patients received bilateral ECT (eight responded, one did not), and two patients received right unilateral ECT (one responded, one did not). Five to six treatments were given during the active phase of the trial. The stimulus-dosing strategy was not fully detailed in the report.

In a prospective naturalistic study, Douyon et al. (1989) studied seven patients with both Parkinson's disease and major depression. Substantial improvement in motor function was noted after only two bilateral treatments. Following an av-

erage of seven bilateral ECT treatments, with "just above threshold" stimulus dosing, mean New York University Parkinson's Disease Rating Scale scores decreased from 65 to 32 (51% improvement). Patients remained well, without further ECT, for 4 weeks to 6 months. Although initial scores on the Hamilton Rating Scale for Depression were determined for all seven patients (all scores were greater than 20), follow-up scores were determined for only four patients (these scores decreased by a mean of 50%). In another prospective naturalistic study, Zervas and Fink (1991) described the ECT treatment of four nondepressed elderly patients with severe, refractory Parkinson's disease. Three of the four patients received bilateral ECT. Stimulus-dosing strategies were not specified. Improvement in parkinsonism rating scores of 20%–40% was observed. Two patients were successfully treated with ongoing maintenance ECT, but once it was discontinued, the parkinsonism returned in both patients within 4–6 weeks. Aarsland et al. (1997) reported on two additional patients whose Parkinson's disease was successfully treated with maintenance ECT, and others have reported its utility for this purpose as well (Krystal and Coffey 1997; Wengel et al. 1998). Finally, ECT has also been found to be effective for neuroleptic-induced parkinsonism (Hermesh et al. 1992).

Because patients with parkinsonism may be at an increased risk of interictal delirium with ECT, we recommend commencing treatment with unilateral nondominant electrode placement. ECT may also be associated with dopaminergic side effects (dyskinesia, psychosis), in which case the dose of levodopa or other antiparkinsonian agents may need to be reduced carefully during the course of treatments. We do not recommend altering the dose of levodopa prior to ECT, because doing so may precipitate severe bradykinesia. Finally, ECT may also be performed safely in patients with Parkinson's disease and a deep brain stimulator, because the brain electrodes do not become dislodged or heated (Bailine et al. 2008).

Brain Tumor or Mass

Intracranial mass lesions and increased intracranial pressure are among the most serious risk factors for ECT. Patients with these conditions are at risk for developing noncardiogenic pulmonary edema, cerebral edema, brain hemorrhage, and cerebral herniation (Krystal and Coffey 1997; Maltbie et al. 1980). ECT may be administered safely and effectively to patients with small or slow-growing intracranial tumors or arachnoid cysts that have no associated swelling or increased intracranial pressure (Abrams 2002b; Coffey et al. 1987). The risks to individuals with more substantial masses may be reduced by surgically removing or debulking the mass when possible, and by trying to diminish the surrounding edema (e.g., steroids, diuretics, or hyperventilation during the treatment) and the rise in intracranial pressure during the treatment (e.g., by pretreatment administration of antihypertensive agents) (Rasmussen et al. 2007b). There is no report of safely delivered ECT prospectively given to a patient with documented increased intracranial pressure (Abrams 2002b). Subdural hematomas may require evacuation before ECT (Abrams 2002b).

Patients with normal-pressure hydrocephalus, including those with a shunt, may be treated safely and effectively with ECT, provided the shunt is determined to be patent, although such patients may be at increased risk of cognitive side effects. These patients (as well as others with prior brain surgery or head injury) may have a skull defect, which may increase the risk of cognitive side effects or injury if the stimulus electrode is placed nearby (allowing greater current density to be administered to the brain). In such cases, repositioning of the stimulus electrode is indicated.

Psychosocial Issues

In addition to its myriad biological effects, ECT has important intrapsychic and interpersonal effects. A powerful treatment, during which the patient is put to sleep and has an electrical stimulus delivered to the head, may arouse predictable fears and fantasies in the patient. Issues of trust and autonomy over one's body while in a vulnerable position may predominate, especially in patients with a history of trauma. Patient education—in particular, educational videotapes—may reduce these fears. Patients who are vulnerable to idealized fantasies of a nurturing, all-caring, supportive other may overvalue the ECT procedure and practitioner. Conversely, these patients may excessively devalue the treatment when their distorted expectations are not realized. Such patients may be at increased risk for a bad psychological outcome from the treatment. The ECT practitioner should challenge overidealization of the treatment, and the informed consent process should be firmly grounded in factual information. We have also found that for some patients, the experience of ECT is markedly improved if a family member or significant other is present during the procedure.

Patient attitude surveys have found that although ECT is poorly understood, those undergoing ECT typically find the experience no more upsetting than a trip to the dentist (Fox 1993; Hughes et al. 1981; Malcolm 1989). These results are limited, however, by a variety of methodological issues (Rose et al. 2003). Only a few studies have systematically examined the effects of age on patients' perception and knowledge of ECT. Malcolm (1989) found that patients over age 65 had less knowledge of the procedure before treatment and were also less fearful of it. In addition, fewer elderly patients viewed the treatment as frightening after completing a course of ECT. Sie-

naert et al. (2005) found no relation between a patient's age and degree of satisfaction with ECT, which in general was quite high even in the presence of memory complaints.

Medicolegal issues surrounding the use of ECT with elderly patients include the informed consent process (discussed earlier in this chapter), do-not-resuscitate (DNR) orders, and consideration of driving after ECT (see Chapter 14, "Ethical and Legal Issues"). A patient with DNR status may still experience improved quality of life with aggressive treatment of his or her affective disorder and may still be considered for ECT (Sullivan et al. 1992). In such cases, strategies for the management of major complications that could occur during ECT should be discussed with the patient and the family before treatment. Patients should not drive after an ECT course until cognitive side effects have substantially resolved (Fink 1994). This issue may be an especially sensitive one for elderly patients who consider driving a means of maintaining their mobility and functional independence.

Financial concerns are of increasing importance in today's cost-conscious health care marketplace. A growing literature suggests that ECT has economic advantages over other forms of treatment for severe mood disorders. The cost-effectiveness of ECT has been demonstrated both for inpatient treatment of the index episode and for maintenance therapy on an ambulatory basis (Markowitz et al. 1987; McDonald et al. 1998; Olfson et al. 1998; Steffens et al. 1995). Despite these advantages, there remains much variation in ECT reimbursement patterns, and it is not uncommon to encounter payers who will reimburse only for ECT when given on an inpatient basis. In addition, reimbursement rates are very low and thus discourage the use of this safe and highly effective treatment.

Novel Techniques for Inducing Therapeutic Seizures

As discussed earlier in the section "Cognitive Side Effects," data suggest that the efficacy and cognitive side effects of ECT may be determined in part by the site of the seizure initiation and by the pattern of seizure generalization. The antidepressant effects of ECT may be correlated with functional changes in prefrontal (among other) brain regions, whereas the amnestic effects of ECT are associated with functional and synaptic changes in the medial temporal lobes. Thus, at least in theory, the goal of the "brain stimulation" specialist is to employ strategies that induce relatively focal seizures in regions that modulate mood (e.g., perhaps the prefrontal region) and that limit spread of the seizure to the medial temporal region.

The use of unilateral nondominant stimulus electrode placement is one such strategy to spatially target the stimulus. Although it produces differences in seizure initiation and spread, as well as substantial differences in cognitive side effects relative to bilateral stimulation, the resultant seizure is still bilaterally generalized. A recent strategy to spatially target even more precisely the electrical stimulus in ECT is known as focal electrically administered seizure therapy (FEAST). This experimental technique couples novel electrode geometry with unidirectional (anode-cathode) stimulation. In nonhuman primates, FEAST has been shown to be a safe and reliable means of inducing a variety of seizure types, from focal to generalized (Berman et al. 2005). Research is under way to determine the applicability of FEAST in humans.

Substantial challenges remain, however, in the use of electrical stimulation to induce focal brain seizures, as a result of the physics of brain stimulation. When electricity is applied directly to the scalp, its flow is impeded by the scalp and the skull, resulting in a "smearing" of the electrical stimulus and a relative broadening of the field of brain stimulation. These factors are likely confounded by individual differences in the anatomy of the scalp and skull, making standardization across patients difficult. Therefore, research has turned to the use of other stimuli to induce a relatively focal therapeutic brain seizure, and among the most promising is magnetic stimulation.

As discussed in Chapter 11, "Brain Stimulation Therapies," seizures may be a side effect of repetitive transcranial magnetic stimulation when administered at high stimulus intensity. This observation has led to the suggestion that repetitive transcranial magnetic stimulation might be used as a means of inducing therapeutic seizures, a technique termed *magnetic seizure therapy* (MST). Relative to ECT, MST would have a theoretical advantage of more precise targeting of the stimulus, because magnetic fields pass through tissue (including scalp and skull) without impedance (i.e., without smearing). In addition, MST typically delivers magnetic stimulation that is relatively superficial, penetrating only ~2–4 cm beneath the scalp. Thus, MST offers the theoretical advantage of relatively more precise targeting of the seizure to superficial cortical structures presumed to mediate mood (perhaps the prefrontal brain region) while at the same time sparing stimulation of deeper structures, such as the hippocampus, associated with amnestic side effects (Lisanby and Peterchev 2007).

Indeed, research in nonhuman primates has demonstrated that 1) relative to electrical stimulation, the current induced by MST is less intense and relatively more discrete; and 2) the resulting seizures are relatively more focal and are associated with less neuroendocrine, autonomic, and neuroplastic responses, as well as with more benign acute cognitive side effects (Spellman et al. 2008). Several dozen patients with depression have now received MST on an experimental basis, and in general they have tolerated the procedure without any major adverse or unanticipated effects (for a review, see Marcolin and Padberg 2007). Consistent with the studies in nonhuman pri-

mates, these patients had more focal and less physiologically "intense" seizures than with ECT, and patients experienced less disorientation and fewer short-term amnestic side effects, at least for some types of memory (i.e., those mediated by the temporal lobes). No differences were seen between ECT and MST seizures in those cognitive functions presumably mediated by prefrontal brain regions. Thus, MST appears feasible and safe, and the fact that it has relatively mild autonomic effects might be a decided advantage over ECT in elderly patients with cardiovascular risks. More research is needed, however, to determine the efficacy of MST and to clarify a host of technical issues (coil selection, parameters of stimulation, pulse characteristics, power requirements, optimal anesthesia, and so forth) that impact the neurobiological effects of this intriguing procedure.

Conclusion

More than 70 years after its introduction, ECT remains a cornerstone of the treatment of severe affective disorder and selected other neuropsychiatric illnesses in elderly patients. ECT also appears to be an effective treatment in patients with preexisting brain disease and in some cases may even have a beneficial effect on the underlying neurological disorder. Continued advances in ECT technique have improved the efficacy of the procedure and reduced the risk of severe side effects. However, few controlled studies have compared the efficacy and safety of ECT versus pharmacotherapy in elderly patients. Further study is needed to determine the impact of age-related changes in brain structure or function and of preexisting cerebral disease on the beneficial effects of ECT in elderly patients. The mechanism of action of this important treatment remains to be fully elucidated.

Key Points

- ECT is an important treatment option for elderly patients with certain neuropsychiatric illnesses. It is most commonly used for the treatment of severe medication-resistant depression. For urgently ill depressed patients, ECT may be used as first-line treatment. It is also used to treat mania, schizophrenia, and catatonia. It is effective in depression-complicating dementia, stroke, and Parkinson's disease. It has also been shown to have a beneficial effect on the motor symptoms of Parkinson's disease.
- The cardiovascular and cerebral physiological changes that occur during ECT are particularly relevant for elderly patients with complex medical illnesses. Modern anesthesia techniques (e.g., using ultra-brief-acting barbiturates, muscle relaxants, and intravenous beta-blockers to control cardiac rate and blood pressure) make the procedure remarkably safe. The cognitive effects of ECT, particularly recent memory loss, may be mitigated by careful attention to technical issues in the administration of the procedure, including the use of right unilateral electrode placement and optimal stimulus dosing.
- ECT is most commonly administered as a series of 6 to 12 treatments targeting acute depressive or psychotic symptoms. It can also be used as a continuation or maintenance treatment, given on an outpatient basis every 1–8 weeks, with the goal of preventing a subsequent episode of illness.
- Novel and still experimental brain stimulation techniques hold out the possibility of inducing more focal cerebral seizures or stimulation but are not yet available for widespread clinical use. Careful attention to patient and family education and the informed consent process are important aspects of making ECT acceptable and nonthreatening to patients.

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