

Review and Update of Anesthetic Management for Electroconvulsive Therapy: A Narrative Review

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Abstract: Electroconvulsive therapy (ECT) is a well-established treatment for severe psychiatric disorders, and its role in modern-day psychiatry continues to expand with rising rates of complex mental illnesses. ECT has proven to be an effective treatment for conditions such as treatment-resistant depression, catatonia, bipolar disorder, schizophrenia, and other serious mental health disorders. Individuals who are resistant to or have contraindications against conventional pharmacologic therapies can particularly benefit from ECT. The procedure involves inducing a brief and controlled generalized seizure by passing an electrical stimulus through a patient's cerebral cortex. The safety of ECT was historically an area of concern due to injuries from the involuntary convulsions during the induced seizure. The use of general anesthesia and adjunct muscle-relaxing agents has made ECT considerably safer in the modern day. The goal of anesthesia in ECT is to induce a quick sedation with adequate depth, to prevent pain and injury from convulsions, and to provide a targeted amnesia. However, many anesthetic agents also function as anticonvulsants and consequently can affect the seizure threshold. The benefits of ECT are inextricably linked to the quality and duration of the induced seizure, therefore, careful consideration must be given to the choice of anesthetic. Alongside its effects on seizure threshold, anesthesia can also affect hemodynamic stability, cardiovascular response, and even the recovery course following ECT. Furthermore, special populations such as elderly patients, pregnant individuals, or those with significant comorbidities require an individual-based approach to anesthetic management. Ultimately, the choice of anesthetic plays an integral role in the therapeutic benefit of ECT. Therefore, strategic management of the anesthetic component of the procedure is critical in improving patient outcomes. This narrative review intends to analyze the dynamic role of anesthesia in ECT by synthesizing current clinical evidence on physiologic changes, pharmacodynamics, procedure optimization, and management of comorbidities and complications.

Plain Language Summary:

- ECT is an evidence-based treatment that provides significant benefits across a wide range of psychiatric disorders.
- Anesthesia in ECT can influence treatment outcomes due to effects on seizure quality, physiologic responses, hemodynamic stability, and recovery.
- Pre-procedure risk assessment, anesthetic planning, intra-procedure monitoring, and consideration of special populations with comorbidities are essential for safe anesthetic use in ECT.
- Thorough understanding and careful management of anesthesia in ECT is integral in ensuring patient safety while retaining therapeutic benefit.

Keywords: electroconvulsive therapy, anesthesia, psychiatric disorders, depression

Introduction

Evolution of Electroconvulsive Therapy

For centuries, researchers have experimented with electricity and seizures for treatment of mental illnesses. The electrical current was first reported to have effects on the nervous system by early Romans, followed by 16th century advancements using camphor oil to induce seizures for psychiatric treatment.^{1,2} The treatment for severe mental illnesses was truly

radicalized in the 1930s by Ugo Cerletti and Lucio Bini, who created a prototype ECT device that used an electric current to induce a seizure.³ While these early interventions showed promising results for mental health treatment, ECT was initially performed without anesthesia and led to traumatic injuries along with severe memory loss.⁴ The induced seizures caused serious convulsions that could result in significant musculoskeletal injuries and even post-traumatic stress disorder (PTSD).^{5,6} In the 1950s, muscle relaxants were combined with anesthesia to prevent these injuries and established the framework for the modern ECT practice used today that prioritizes patient safety through adequate sedation and targeted amnesia.^{2,7} Within a broader context of modern day transcranial neuromodulation therapies, ECT is distinctly effective compared to therapies such as transcranial magnetic stimulation (TMS), that shows limited efficacy in many individuals.⁸ Furthermore, TMS is markedly nonconvulsive, whereas ECT intentionally induces the generalized seizure and therefore uniquely requires general anesthesia along with neuromuscular blockade.⁹ This makes anesthetic management and neuromuscular blockade in ECT fundamental to therapeutic efficacy, not as an adjunct but as a foundational component of modern ECT practice.

Indications for Use of ECT

In current clinical practice, ECT is considered first-line for severe depressive episodes that have psychotic features, catatonia, high suicide risk, and/or food or fluid refusal.^{10,11} Furthermore, it is used as second-line treatment for treatment-resistant depression, which encompasses major depressive episodes that persist despite multiple trials of typical pharmacotherapies.^{10,12,13} Due to its mood-stabilizing effects, ECT can also be indicated in those with mania refractory to other treatments.¹¹ Studies have demonstrated that ECT can relieve psychiatric symptoms in 70–90% of cases and can provide up to 90% symptom relief within 2 weeks of treatment.^{14,15} Retrospective observational studies have shown efficacy rates of 80 to 100% in those with catatonia.¹⁶ In patients with schizophrenia, ECT is most effective at treating positive symptoms, though some studies report benefits across both positive and negative symptoms.^{11,17} Despite the potential benefits of ECT, the procedure is still significantly neglected as a treatment when it comes to clinical application. When analyzing a population of privately insured patients, it was found that less than 1% of those with mood disorders received ECT.¹⁸ This highlights the potential underutilization of the procedure in modern practice. ECT is fundamentally linked to tailored anesthetic management, therefore anesthetic considerations are integral in safe and effective clinical application of the procedure.

Rationale for Anesthetic Focus

Selecting the optimal anesthetic for ECT is essential because these agents can impact the quality of the induced seizure and thereby affect treatment outcomes. Many intravenous anesthetics have anticonvulsant properties and may interfere with seizure induction and/or duration once an electrical stimulus is applied.¹⁹ To properly choose an anesthetic, clinicians should prioritize characteristics such as quick onset, adequate sedation, minimal effects on physiology and hemodynamics, and rapid recovery.²⁰ Post-procedure recovery is particularly an area of concern, as cognitive impairment is a common side effect after ECT and may be exacerbated by anesthesia.²¹ Muscle-relaxing agents are commonly used in adjunct with anesthesia to prevent involuntary muscle contractions during the induced seizure, but these agents should also be used with caution due to risk of pulmonary aspiration, respiratory failure, and residual motor paralysis.²² While anesthetics can interfere with the procedure, studies have proposed that anesthetic agents can also be used to supplement ECT if the proper seizure threshold cannot be achieved with ECT alone.²³ The ideal anesthetic should maximize therapeutic benefit while maintaining a strong safety profile. Despite the advancements in the use of anesthesia in ECT, there are still unresolved considerations regarding specific anesthetic selection, dosing, adjunct medication choice, hemodynamic fluctuations, comorbid factors, and more. Furthermore, the variability due to balance between individualized-based treatment strategies versus standard protocol treatment highlights the need for a comprehensive overview of current evidence to inform clinical decision making. These considerations provide the foundation for a narrative review that uses synthesizing methodology on existing evidence relating to anesthetic pharmacology, peri-operative management, and considerations of medically complex populations to clarify the central role of anesthesia in modern ECT practice. While existing literature primarily focuses on psychiatric indications, outcomes, and technical procedure management, this review distinctly centers anesthesia as an integral component to clinical application of ECT.

Anesthetic Management in ECT

Goals of Anesthesia in ECT

The overarching goal of the anesthesia team in ECT is patient comfort and safety. As previously discussed, anesthetic management during this procedure includes general anesthesia in addition to a muscle relaxant. Because an induced seizure can be distressing for patients, it is essential for patient well-being that they are sedated. Furthermore, making this experience as non-traumatic as possible ensures patient cooperation and improves treatment adherence. Reducing post-procedural unease is also a priority because conscious awareness during the procedure could worsen patient outcomes. Muscle relaxants help reduce the risk of injury to the patient during seizure induction. Continuous vital sign monitoring should be done throughout the procedure to ensure hemodynamic stability. Depending on the chosen anesthetic, patients can be at risk of inadequate seizure quality and hemodynamic fluctuation.

Physiologic Changes

The physiologic changes that occur during this procedure happen in three phases: an initial parasympathetic dominant phase, a period of sympathetic activation, and a final phase of parasympathetic dominance.²⁴ Following the electrical impulse, there is initially a parasympathetic stimulation accompanied by bradycardia and hypotension, with particularly serious procedural complications including arrhythmias and asystole.⁴ As the seizure starts, the sympathetic nervous system predominates and causes a rise in blood pressure and heart rate.²⁴ Because of these adrenergic effects, caution should be used in those with underlying cardiovascular comorbidities. Administration of anesthetic agents and adjunct medications such as muscle relaxants, anticholinergics, and beta-blockers, can mitigate these autonomic fluctuations in order to maintain hemodynamic stability.²⁰ ECT also induces an increase in cerebral blood flow, intracranial pressure, intraocular pressure, and cerebral oxygen consumption, but these effects are transient, and patients tend to return to baseline quickly afterwards.²⁰ The underlying mechanism behind these changes and why they occur in this sequence is not fully understood and warrants further investigation. However, these expected physiologic changes should inform the anesthetic choice, dosing, and management as anesthesia may be critical in modulating autonomic responses.

Anesthetic Agents Commonly Used in ECT

Many properties of anesthetic agents should be taken into consideration when using them for ECT, namely duration of action, impact on seizure threshold, and impact on hemodynamic stability. Many anesthetics also function as anticonvulsants, and this dose-dependent influence on the quality of seizure thereby necessitates that the minimum effective dose be used.²⁵ The most utilized anesthetic agent for this procedure is methohexital, a gamma-aminobutyric acid type A (GABA-A) receptor stimulator that increases inhibitory transmission in the brain.²⁶ Methohexital has a rapid onset and little impact on seizure threshold.^{27,28} Thiopental, another GABA-A agonist, is less ideal due to its longer duration of action, potential to shorten seizure duration, and longer recovery period compared to methohexital.²⁰ Furthermore, it can cause hemodynamic changes and shows to have an increased incidence of cardiac arrhythmias compared to propofol and sevoflurane, respectively.^{29,30} Etomidate, another GABA-A agonist, is known to prolong seizure duration and thereby would be effective in settings of decreased seizure duration.³¹ However, adverse effects include post-procedure confusion, delirium, nausea and vomiting.^{27,28,31} While propofol, which also acts as a GABA-A agonist with some glutamate blocking activity, is commonly used in many other operative settings due to reduced recovery period and antiemetic effects, it has marked anticonvulsant properties that significantly reduce seizure duration.²⁰ However, propofol does have inhibitory effects on the cardiac system, which can make it beneficial in those with hypertension or tachycardia.³² Ketamine is a NMDA receptor antagonist that blocks inhibitory transmission and shows to have dose-dependent effects on seizure properties, with higher doses (1–2 mg/kg) achieving optimal ECT results but low doses (0.4–0.8 mg/kg) causing reduced seizure duration.²⁰ Furthermore, ketamine has hemodynamic influence and can cause hypertension, tachycardia, and increased intracranial pressure.^{25,33} Ketamine also has psychiatric indications such as dissociative effects, delirium, and hallucinations.²³ Esketamine, an enantiomer of ketamine that enhances activation of the PI3K/AKT/GLT-1 pathway, has shown to significantly improve depressive behaviors in conjunction with ECT, although clinical evidence is inconsistent.^{8,34} Understanding hemodynamic responses to anesthetic induction are integral in

Table 1 Summary of First-Line Drugs Used in ECT

Drug Name	Drug Class	Mechanism	Role in ECT
Methohexital ²⁶	Anesthetic	GABA-A receptor agonist	Induction
Succinylcholine ²⁰	Muscle relaxer	Depolarizing neuromuscular blocker	Muscle relaxation
Glycopyrrolate ²⁰	Anticholinergic	Muscarinic receptor antagonist	Decrease risk of bradycardia and airway secretions
Esmolol ^{20,37}	Beta-blocker	β 1 receptor antagonist	Attenuate tachycardia and hypertension

ensuring patient safety. Methohexital has few effects on hemodynamics, and was shown to cause some decreased blood pressure post-anesthetic induction but prior to electrical stimulus application.²⁰ Thiopental, on the other hand, caused increased heart rate along with decreased blood pressure and cerebral blood flow.²⁰ Etomidate did not show any significant effects on physiology, but propofol induced decreased heart rate, blood pressure, and cerebral blood flow.²⁰ Ketamine demonstrated effects such as increased heart rate, decreased blood pressure and cerebral blood flow.²⁰

Despite the influence of anesthetic agents on seizure thresholds, understanding the positive and negative effects can allow providers to modulate scenarios in which patients do not achieve the proper seizure duration. Agents that reduce seizure duration can be used to augment treatment in patients who have particularly longer ECT-induced seizures such as adolescents and young adults. On the other hand, in patients with shorter seizure durations can be administered anesthetic agents that are known to prolong seizures. Along with choosing the ideal anesthetic, adjunct medications like muscle relaxants are key to keeping the procedure safe and controlled.

Adjunct Medications

As noted above, due to the impact on the autonomic nervous system and to ensure a patient's well-being during seizure induction, other therapies are employed to maintain patient safety. Muscle relaxants such as succinylcholine, a depolarizing neuromuscular inhibitor, can induce paralysis to prevent motor response to the electrical impulse and prevent patient injury.²⁰ Its rapid onset and duration make it ideal for a short procedure like ECT. Although succinylcholine is first-line, low-dose atracurium, a non-depolarizing neuromuscular inhibitor, can replace succinylcholine if it is contraindicated.³⁵ Rocuronium is another non-depolarizing neuromuscular inhibitor with a longer duration of action, which alone may not be ideal for ECT.²⁰ However, when used in combination with sugammadex, it can be rapidly reversed and is being explored as a potential alternative to succinylcholine.²⁰ To prevent bradycardia, other cardiac effects, and to reduce airway secretions, anticholinergics such as glycopyrrolate offer great benefit in improving patient outcomes.²⁰ Beta-blockers, such as esmolol, also help control the cardiac response to the autonomic nervous system, particularly the sympathetic stimulation that comes with the electrical brain impulse.²⁰ Boere et al suggests that while esmolol does not have a significant impact on seizure duration, this may be dose dependent.³⁶ By carefully selecting and/or combining these adjunct medications, clinicians can better manage physiologic responses during ECT and enhance both safety and treatment outcomes. See Table 1 for Summary of First-line Drugs used in ECT.

Perioperative Management Strategies

Pre-Procedure Assessment

ECT is conducted in a controlled hospital environment with a multidisciplinary team that typically includes a psychiatrist, an anesthesiologist, and nursing staff.⁴ Many factors that influence anesthetic selection and seizure quality must be taken into account before conducting ECT such as patient age, skull thickness, adjunct pharmacologic interventions, hyperventilation, and biological sex.²⁰ ECT may further exacerbate patients' underlying conditions, particularly those with cardiovascular comorbidities, due to the impact the electrical stimulus has on the autonomic nervous system. This, coupled with the intra-procedural seizure induction, indicates the necessity of thorough medical history taking emphasizing cardiovascular and neurological history.³⁸ It is also important to perform a comprehensive metabolic panel and renal function tests to evaluate electrolytes, particularly sodium and potassium, which could be

useful in evaluating unexpected conditions that could impose risk during the procedure.³⁹ Ultimately, a comprehensive pre-procedure assessment lays the foundation for safe anesthesia induction, and careful coordination among the multi-disciplinary team ensures that ECT is delivered efficiently with anesthetic management playing the integral role in ensuring safety and minimal discomfort to the patient.

Anesthetic Induction and Procedural Outline

Prior to ECT, standard protocol is upheld as for any other procedure or surgery that would occur under general anesthesia. Patients abstain from eating or drinking for at least 8 hours leading up to the procedure.²⁰ A pre-anesthesia airway function evaluation is also necessary to ensure proper airway protection, ventilation, and management of respiratory secretions when patients undergo general anesthesia as unsuccessful airway management can lead to complications and death.⁴⁰ Due to the high frequency and short duration of ECT treatments, a bag-valve ventilation system is typically used rather than tracheal intubation, along with an oxygen face mask.^{20,23} Typically, intravenous anesthetics are used over inhalation anesthesia due to shorter induction time for the rapid ECT procedure.²⁰ In special circumstances, such as severe agitation preventing intravenous catheter insertion or poor intravenous agent tolerance, inhalation techniques can be used for anesthetic induction particularly with sevoflurane or nitrous oxide.⁴¹ After the anesthetic is administered intravenously, hyperventilation with the bag-mask is induced in order to cause hypocapnia, reducing cerebral blood flow and decreasing the seizure threshold.²³ A muscle relaxant is administered following successful induction of anesthesia, along with application of a tourniquet typically on a lower extremity to block spread of the muscle relaxants and allow monitoring through muscle convulsions.²³ A specialist then places unilateral or bilateral scalp electrodes and delivers a short, controlled electrical stimulus to the brain to trigger a generalized tonic-clonic seizure in the brain lasting at least 20 seconds, though the body remains relatively still due to the effects of muscle relaxants administered.⁴

Intra-Procedural Monitoring

The main monitoring strategy during ECT is electroencephalography (EEG) to record seizure duration, alongside typical monitoring of other vitals such as blood pressure, pulse oximetry, and ventilation.⁴ Furthermore, the EEG can monitor the quality of the seizure and assess any changes that need to be made to the electrical impulse throughout the procedure.⁴ Bispectral Index (BIS) essentially is a tool that measures how “deep” a patient is under anesthesia and proves beneficial for summarizing and analyzing EEG data.⁴² Pre-ictal BIS was positively correlated with seizure duration and could even be used to predict seizure duration in those undergoing propofol anesthesia and thereby experiencing increased seizure threshold.⁴³ Patient State Index (PSI) is another method to assess the depth of sedation, and has been used to determine the optimal moment to apply the electrical stimulus in order to counterbalance the anesthetic effects, particularly of propofol, on seizure threshold.⁴⁴ Thorough and continuous monitoring during the procedure is essential as many of the anesthetic agents used in the procedure can have an impact on these vitals. For example, the sympathetic stimulation can impact blood pressure and heart rate. Continuous electrocardiogram (ECG) monitoring can also be used to look for arrhythmias, which are also a risk associated with ECT.⁴ Careful monitoring allows for optimal seizure quality while preserving patient safety, particularly in anticipation of the hemodynamic changes that often accompany ECT.

Managing Hemodynamic Fluctuations

There are several pharmacologic interventions that can be used to manage hemodynamic fluctuations during an ECT procedure. An initial upstroke in parasympathetic activity can put patients at risk for bradycardia and hypotension immediately following the electrical stimulus. Glycopyrrolate can help mitigate these effects as it acts as a muscarinic antagonist, thus blocking the effects of acetylcholine in the parasympathetic nervous system.²⁰ Contrastingly, because hemodynamic fluctuations can be caused by stimulation of the sympathetic nervous system, another management method is the use of beta-blockers like esmolol. Esmolol is a selective beta-1 adrenergic receptor antagonist and is useful in managing increases in heart rate and contractility without major impact on pulmonary function.³⁷ This is important for those undergoing general anesthesia as inhibition of beta-2 receptors can cause bronchospasm, which could cause airway

complications.³⁷ Overall, careful selection of pharmacologic agents to balance autonomic responses is crucial to preserving cardiovascular stability throughout ECT.

Clinical Considerations and Special Populations

Electroconvulsive therapy (ECT) is performed across a diverse patient population, and anesthetic management must be tailored to each individual's physiological and medical context. While the fundamental goals of anesthesia— rapid induction, adequate sedation, and prompt recovery— remain the same, specific considerations are required in each patient population to limit side effects.

Elderly and Pregnant Populations

ECT has demonstrated efficacy and safety in older adults with severe or treatment-resistant psychiatric disorders. Studies have shown that ECT often produces faster and greater antidepressant responses in elderly patients compared to younger populations, with minimal risks or serious adverse events.⁴⁵ Transient increases in blood pressure and mild arrhythmias may occur more frequently in older individuals, but these effects are typically well-managed with perioperative monitoring.⁴⁵ For patients who are unable to tolerate pharmacological therapy due to drug toxicity, poor metabolism, or polypharmacy, ECT offers a safer alternative.⁴⁶ Notably, cognitive performance following ECT in the elderly tends to remain stable or even improve, particularly in domains of attention and verbal learning with fewer memory disturbances than in younger patients.⁴⁵ These findings highlight that when guided by individualized anesthetic dosing and vigilant control, ECT remains a highly effective and well-tolerated treatment for late life mood and psychiatric disorders.⁴⁶

ECT also represents a treatment option for pregnant individuals experiencing psychiatric disorders when other pharmacological interventions are contraindicated or ineffective. Untreated depression and psychosis during pregnancy has a risk for both the mother and fetus, including malnutrition, poor prenatal care, and increased risk of suicide.⁴⁷ Over decades of clinical use, ECT has shown to be beneficial and safe during pregnancy when performed under carefully controlled conditions. Most reported cases involved administration during the second trimester, with depression or bipolar disorder as the leading indications.⁴⁸ While adverse obstetric events such as fetal heart rate changes, uterine contractions, and labor have been documented, these remain uncommon and typically resolved without long term issues. Importantly, no consistent evidence links ECT to congenital anomalies or neurodevelopmental harm in offspring.⁴⁷ ECT serves as a safe intervention in carefully selected pregnant patients.^{47,48} The importance of individualized treatment is made evident in elderly and pregnant patients, who may require careful tailoring of ECT and anesthetic management.

Cardiovascular Disease and Neurologic Conditions

An individualized approach to ECT and anesthetic management is even more critical when addressing underlying cardiovascular and neurological comorbidities. Studies have shown that with careful multidisciplinary planning and monitoring, ECT can be safely administered in patients with severe cardiomyopathy. In a case by Luo et al, a 68 year old man with an ejection fraction of 14% tolerated a full ECT series without major complications and experienced significant improvement in mood and function, demonstrating that ECT remains a viable option even in high-risk cardiac patients.⁴⁹ Patients with serious cardiac disease may, however, experience transient arrhythmias or blood pressure changes during ECT but most complete treatment without long term complications.⁵⁰ ECT has shown to be low-risk and beneficial for patients with neurological disorders as well when medical risks are assessed. It can treat affective and catatonic symptoms even in those with conditions such as Parkinson's disease and behavioral disorders following a brain injury, demonstrating its benefits.⁵¹ With individualized strategies and careful oversight, ECT can safely extend its therapeutic benefits to more medically complex patients.

Interactions with Psychiatric Medications

Concomitant use of psychotropic medications during ECT is common, particularly for patients with treatment-resistant depression. While guidelines on combining antidepressants with ECT are not consistent, many clinicians continue this practice to enhance treatment-related effects.⁵² Evidence suggests that continuing antipsychotic medications during ECT is generally safe and does not increase adverse effects, though more research is needed to clarify the impact on efficacy

and cognitive outcomes.⁵² Overall, the interplay between ECT and concomitant use of psychiatric medications shows promise but still remains an area for ongoing study.

Complications and Risk Mitigation

Electroconvulsive therapy is a generally safe and well-tolerated treatment, however, both minor and serious adverse effects are still common and must be considered while utilizing this approach to ensure optimal patient outcomes while on treatment. Common transient side effects include headache, nausea, myalgia, and postictal confusion, which are typically self-limited and managed symptomatically.⁵³ Cognitive effects, including anterograde retrograde amnesia along with impairment of autobiographical memory, can be more persistent in some patients, with severity influenced by electrode placement, pulse width, and stimulus dose.⁵⁴ Serious complications are rare, but may include cardiovascular events, prolonged seizures, status epilepticus, respiratory compromise, and cerebrovascular events.⁵⁵ Historically, unmodified ECT was associated with musculoskeletal injuries such as fractures or dislocations, but modern practice with anesthesia and muscle relaxation has substantially reduced these risks.⁵⁵ Large scale analyses of thousands of ECT treatments demonstrate that life-threatening adverse events are uncommon, occurring in less than 0.1% of cases and generally reversible with prompt intervention.⁵⁵ Cardiovascular monitoring is essential for patients with arrhythmias or atrial fibrillation, as ECT can induce transient rhythm changes or conversion between arrhythmias and sinus rhythm, and individualized anticoagulation planning is recommended.⁵⁶ Additional physiological risks may arise in patients with recent myocardial infarction, deep vein thrombosis, intracranial aneurysm, tumors, pheochromocytoma or pregnancy. While mortality directly attributed to ECT is rare, these conditions warrant heightened precaution, thorough risk assessment and multidisciplinary management.⁵⁷ Comprehensive procedural planning and risk mitigation involves pre-treatment medical evaluation, anesthetic planning, physiological monitoring during procedures, clear contingency protocols, and collaboration among psychiatric, and anesthesia. Communication with patients and families regarding potential risks, along with education for the ECT providers further mitigates risks. When these measures are implemented, ECT maintains a favorable safety profile even in medically complex populations, allowing patients to benefit from its therapeutic effects while minimizing potential complications.⁵⁷

Emerging Approaches in ECT Anesthesia

New Agents and Adjunct Medications

Recent advances in ECT research have focused on improving safety and efficacy, particularly in high-risk populations such as the elderly, pregnant, and patients with COVID-19 related neuropsychiatric conditions.⁵⁸ Modifications in anesthetic choice, anesthetic timing, depth of anesthesia, and airway management have also been shown to influence treatment outcomes, which highlights the importance of procedural planning.⁷ Subanesthetic intravenous ketamine has emerged as a promising alternative to traditional methods used in ECT, demonstrating noninferior efficacy for treatment-resistant depression with faster onset of antidepressant effects and even fewer cognitive side effects.⁵⁹ Esketamine, an enantiomer of ketamine, showed promising results at low doses and particularly benefited those with suicidal ideation and anhedonia.⁸ Although these new methods may have limited use due to individuals with drug abuse or psychotic disorder considerations.⁸ New anesthetic approaches in ECT emphasize improving seizure quality and reducing cognitive side effects.⁶⁰ Etomidate enhances seizure efficacy compared to propofol, while ketamine may improve cognition and seizure quality.⁶⁰ The emergence and investigation into novel drugs demonstrates that ECT has potential to become even safer and more effective, which sets the stage for more personalized treatments for each patient.

Personalized ECT

There is an ongoing debate in ECT practice on whether there is a need to employ a standardized treatment protocol or individualized therapy based on patients' characteristics. Personalization may involve modifying electrode placement, pulse width, or dosing strategy to optimize therapeutic efficacy while minimizing cognitive adverse effects.⁶¹ Treatment adjustments and existing evidence supporting these individualized adjustments remain limited however, but there is evidence of using multiple courses of ECT. Some patients who did not respond to initial ECT often improved after

a second course of using high dose, brief pulse ECT with remission rates up to 60%.⁶² The benefit was independent of first ECT type, suggesting that longer ECT courses could help some patients depending on their needs.⁶² Recent data shows that seizure duration decreases over the course of ECT especially during the early sessions.¹⁹ Shorter seizures are linked to older age, higher doses, and cumulative treatments demonstrating the uniqueness of each patient.¹⁹ Personalized ECT highlights the potential to tailor treatment to individual patients, emphasizing flexibility and ongoing refinement of therapeutic strategies.

Discussion

ECT and Anesthetic Considerations

ECT is a well-established, evidence-based treatment that has proven to be a successful therapy for severe psychiatric illnesses. Not only can ECT function as a useful alternative in those resistant to or with contraindications against typical pharmacotherapies, but ECT is further considered first-line in a variety of cases. These cases include but are not limited to conditions such as treatment-resistant depression, bipolar disorder, schizophrenia, or depressive conditions with severe features such as psychosis, catatonia, high suicide-risk, food/fluid refusal, etc.¹⁰ Due to the nature of ECT inducing a mild seizure, anesthetic management is necessary to provide a safe environment. However, the treatment outcomes of ECT can be heavily influenced by this anesthetic management.

Anesthesia plays a pivotal role in the application of ECT in modern day medicine. The application of an electrical stimulus into a patient's cerebral cortex to induce a generalized seizure undeniably poses risks. Most evident of these risks being the muscle convulsions caused by the seizure that could injure a patient. The addition of anesthesia and adjunct muscle relaxants subverts this potential issue. The main goal of anesthetic management in ECT is patient safety, comfort, and ultimately to avoid distress during the induced seizure. However, the use of anesthetic agents in and of itself poses alternate risks that must be considered.

Physiologic, Procedural, and Comorbidity Insights

Despite the benefits of anesthesia in providing a safer environment for ECT, these agents have the potential to interfere with the procedure. The quality and duration of the induced seizure is a key component of ECT. Anesthetic agents typically have anticonvulsant properties, and thereby potentially could affect these treatment outcomes. Furthermore, anesthesia plays a role in hemodynamics, cardiovascular response, and even post-procedure recovery. ECT can be delineated into three distinct stages correlating with an autonomic nervous system response—parasympathetic activation, then sympathetic, and finally parasympathetic again.²⁴ Bradycardia and hypotension accompany the parasympathetic response, and conversely tachycardia and hypertension are induced by the sympathetic response.²⁴ Different anesthetic agents can amplify or diminish these physiologic reactions based on their pharmacologic mechanisms.

Appropriate pre-procedure planning and intra-procedure monitoring can mitigate the risks associated with these physiologic fluctuations. Proper monitoring during the ECT procedure can be accomplished with the use of EEGs, ECGs, vital monitors, and even the Bispectral Index to measure depth of anesthesia.^{42,43} These techniques are integral in ensuring that adverse events are caught immediately for prompt intervention. In the event of an adverse reaction, standardized protocols for contingencies should be implemented for proper management. Adjustments in anesthetic technique, dosage, and monitoring can significantly improve seizure quality, patient experience, and ultimately treatment outcomes. These adjustments should further consider special populations who may need more careful planning when it comes to anesthetic management. Particularly populations such as the elderly, pregnant individuals, and those with cardiovascular, respiratory, or neurologic comorbidities should be given extra consideration. Thorough risk assessments along with proper planning can ensure patient safety while balancing clinical application of ECT.

Knowledge Gaps and Future Directions

Despite the vast expanse of research and the long history of advancements in ECT, there are various domains that necessitate further investigation. Although the major physiologic responses to ECT are well-established, the underlying mechanisms are incompletely understood. For example, transient increases in cerebral blood flow, intracranial pressure,

and intraocular pressure are areas that warrant further studies.²⁰ A deeper understanding of these responses could potentially enable more precise management of risks and adverse effects. Another area for advancement is anesthetic choice based on an individualized risk assessment. Future research could explore novel combinations of anesthetic agents and muscle-relaxants that could synergistically provide better outcomes than either agent alone. For example, esketamine is emerging as a novel agent to be used with ECT, but also as a monotherapy in subanesthetic doses, though clinical data is still inconsistent. The balance between standardized treatment protocols and individualized-based therapy is an area that needs further exploration due to limited existing evidence. Further investigation into anesthetic components of ECT not only reduces risk but also enhances seizure efficacy and ultimately improves efficacy.

Conclusion

ECT remains one of the most effective treatments for various psychiatric disorders, particularly those with severe features that are refractory to typical therapies. Optimizing the anesthetic component of this procedure can significantly improve therapeutic outcomes. With the proper evidence-based measures implemented, there is a potential to further evolve the efficacy and reliability of ECT. This narrative review explores four key areas for ECT optimization— pre-procedure evaluation, proper selection of anesthetic agent, intra-procedure monitoring of physiologic changes, and risk mitigation based on comorbidities –in order to give insight into clinical decision making by centering anesthesia as an integral component necessitating thoughtful consideration. Understanding the role of anesthesia in ECT is integral in successful clinical application of the procedure while enhancing patient safety and maximizing treatment outcomes.

Compliance with Ethical Guidelines

This article is based on previous studies and contains no new studies with human participants or animals performed by any authors.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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