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Around anesthesia: anesthetic aspects of electroconvulsive treatment in the light of the latest reports – review article

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Summary

Electroconvulsive therapy (ECT) remains the most effective method of treating acute mental conditions in psychiatry. The progress that has been made in anesthesiology in recent years allows for the personalization and optimization of electroconvulsive therapy through purely anesthetic interventions. There are few procedures in medicine where anesthesia would have such a direct impact on the effectiveness, or even success, of a given procedure.

A key aspect of electroconvulsive therapy is a selection of the appropriate anesthetic. In Polish conditions, we have a choice of thiopental, propofol, etomidate, and ketamine – each with different, unique properties and a different impact on the generated epileptic seizure and the patient's hemodynamic safety. From the psychiatrist's perspective, etomidate and ketamine seem to be optimal, as they have no anti-epileptic effect and allow the use of lower energy values, which translates into a lower risk of cognitive dysfunction. However, their use is associated with more frequent cases of hypertension and tachycardia. Ketofol, a mixture of ketamine and propofol, helps to alleviate excessive increases in blood pressure and pulse rate through the hemostabilizing property of propofol.

Another important issue is the dose of the anesthetic used, i.e., the depth of anesthesia, which can be monitored using the bispectral index. Too deep anesthesia will result in less effectiveness of the procedure itself. The flow of the electric current requires the patient's muscles to be fully relaxed. Succinylcholine, which is a depolarizing muscle relaxant, remains the drug of choice. In the case of contraindications to its use, non-depolarizing agents, such as mivacurium or rocuronium, turn out to be useful, although the duration of the procedure is definitely longer. Sugammadex allows for full abolition of rocuronium-induced relaxation, but it remains a drug that is usually unaffordable.

Key words: anesthesia, electroconvulsive therapy

Introduction

Agents that modulate the autonomic response

Immediately after the electrical impulse is delivered, extreme stimulation of the vagus nerve occurs, which leads to parasympatholysis, bradycardia, transient hypotension and electrical interruption, which lasts more than 5 seconds in approximately 5% of patients [1–3]. It is believed that asystole longer than 10 seconds may pose a threat to the patient. A greater risk of prolonged electrical pause has been associated with the use of beta-blockers, high doses of suxamethonium, the use of thiopental as an anesthetic, bilateral electrode placement, and repeated subthreshold stimulation [4]. Prolonged asystole, which may pose a threat to the patient, can be prevented by intravenous premedication, usually immediately before the procedure itself, with the use of anticholinergics, mainly atropine (usually in doses of 300 to 600 μg) [5]. Glycopyrronium bromide turns out to be a substance with a more favorable action profile in this indication, as it does not cross the blood-brain barrier, giving a lower risk of cognitive disorders, but in Poland it is available only in inhalation form as a drug used in lung diseases [6, 7]. Atropine, in addition to its effect on heart rate, reduces salivation after ECT, which may be particularly useful in patients treated with clozapine to minimize the risk of aspiration pneumonia [8].

During the clonic phase of an epileptic seizure, the levels of catecholamines in the adrenal medulla increase up to 15 times, which leads to tachycardia and an increase in blood pressure [9]. The substance used to lower blood pressure during ECT is urapidil (usually an i.v. bolus of 25mg), which is a fast-acting postsynaptic α1-adrenoceptor antagonist, although so far we have only one study comparing its effectiveness with other agents more frequently used in this indication, such as esmolol (usually 1 mg/kg) or labetalol (usually 0.2 mg/kg) [10, 11].

Choice of anesthetic agent

The choice of an anesthetic is one of the most important decisions during ECT procedures and can often determine the effects of treatment. Wagner et al. [12] summed up the features that an ideal anesthetic should have: quick and smooth induction of anesthesia, painless injection, no or minimal anti-epileptic properties, short duration of action, and a synergistic or additive effect to ECT alone. In Poland, the anesthetics that are used during ECT include thiopental, propofol, etomidate, and ketamine, which differ greatly in their properties [13].

By influencing GABA-ergic transmission, both thiopental and propofol significantly increase the seizure threshold [14]. This is associated with a greater number of abortive seizures, a shorter duration of epileptic activity and, as a result, the need to use higher electrical charges. The effect is more expressed with the use of propofol due to the additional blocking of sodium channels [15]. Ketamine and etomidate, on the other hand, have no or minimal antiepileptic effect [16, 17].

Hoyer et al. [18] compared the agents used to induce anesthesia in terms of their impact on the quality of the epileptic seizure and the profile of side effects. In the group

of patients receiving ketamine and etomidate, the effectiveness of epileptic seizures was definitely higher, it turned out to be lower with thiopental and the lowest with propofol, in the case of which almost 14% of all seizures were classified as probably ineffective. These reports coincide with many others proving the advantage of ketamine or etomidate over anesthetics with antiepileptic properties [19]. On the other hand, propofol and thiopental provide the best hemodynamic stabilization, preventing post-ictal increases in blood pressure and tachycardia [20, 21].

The use of inhalation anesthetics for electroconvulsive therapy remains debatable. In a recent comparison of sevoflurane with thiopental, it was shown that its use was associated with a higher percentage of unsuccessful procedures, more frequent need for restimulation, higher increases in maximum heart rate, and a greater number of necessary procedures [22, 23].

Specific properties of ketamine

Ketamine is a non-selective NMDA receptor antagonist with intrinsic antidepressant activity, although the mechanism of this action remains unclear [24]. In psychiatry, it was not used for many years due to its potential to cause dissociative symptoms, including visual and auditory hallucinations [25]. However, this is a dose-dependent effect, ketamine shows psychomimetic properties at plasma concentrations from 100 ng/mL to 250 ng/mL, while its concentrations during general anesthesia exceed 2,600 ng/mL [26]. So far, no worsening of symptoms in patients with schizophrenia or schizoaffective disorders has been reported [27].

What distinguishes ketamine from other agents is its effect on the cardiovascular system, it inhibits the respiratory center to a much lesser extent, only slightly reduces laryngeal reflexes, increases blood pressure and heart rate [28]. In addition, it strongly dilates the bronchi (similarly to propofol), which may prove beneficial in people with asthma or chronic obstructive pulmonary disease, while etomidate and thiopental have the opposite effect due to a greater or lesser effect on the release of histamine [29].

Despite theoretical premises and preliminary reports on the additive effect of ketamine on ECT, current research brings ambiguous results. A recent double-blind RCT under the acronym KANECT did not show any advantage of ketamine over propofol in terms of the effectiveness of ECT [30]. Also, the addition of small subanesthetic doses of ketamine to anesthesia with another anesthetic did not increase the effectiveness of ECT, was not associated with a faster resolution of symptoms, and did not significantly affect the cognitive functions of patients [31, 32].

The combination of ketamine and propofol in one mixture is common in anesthesiology under the name of "ketofol" and is particularly used during ECT procedures [33–35]. Ketamine provides a lower seizure threshold, which results in the possibility of using smaller electric charges, and this translates into a reduced risk of cognitive dysfunction [36]. Propofol, on the other hand, limits post-ictal increases in BP and HR, which also reduces the risk of cognitive dysfunction and the risk of postoperative agitation [37]. In anesthesiology, ketofol is usually used as a 1:3 mixture of ketamine to propofol [38]. Sartorius et al. [39], in a retrospective evaluation of various mixtures

of ketofol, showed that from the point of view of ECT, the most favorable ratio of ketamine to propofol is 3:1 or 1.5:1 with S-ketamine.

Specific uses of anesthetic agents

Although the risk of a prolonged epileptic seizure exceeding 120 seconds (or 180 seconds according to other authors) is not high and amounts to about 0.4%, it may be associated with severe cognitive impairment and prolonged awakening [19, 20]. A single bolus of an anesthetic with anticonvulsant properties, such as propofol (usually 30–50 mg) or thiopental (usually 50–100 mg) or benzodiazepines (e.g., 1 mg of clonazepam or 10 mg of diazepam) is most often used to stop an epileptic seizure [40–42]. So far, 13 cases of generalized non-convulsive and 3 cases of ECT-induced seizures have been described [43]. In cases of prolonged epileptic seizures resistant to pharmacological actions, epileptic activity can be interrupted using electrical stimulation with a charge at least twice as high as applied [44].

Dexmedetomidine, a selective central α2 receptor agonist with a strong sedative and analgesic effect, is a substance that is particularly used during ECT procedures [45]. A significant complication of ECT procedures is post-ictal agitation (PIA), which may occur in up to 12% of all patients and usually requires additional interventions [46]. Premedication with dexmedetomidine prior to ketamine anesthesia reduces the risk of developing PIA by almost half [47]. Moreover, it alleviates the hemodynamic response during an epileptic seizure, significantly reduces the maximum systolic and diastolic blood pressure and heart rate, while not affecting the time to awakening or prolonging the electrical interval after the flow of an electrical impulse [48].

In situations where there are contraindications to replacing the anticonvulsant anesthetic with etomidate or ketamine, and with a high seizure threshold, it may be beneficial to add short-acting opioids, taking advantage of their opioid sparing effect, which allows to reduce the dose of propofol or thiopental necessary for induction [19, 20]. Adding, e.g., remifentanil (1 μg/kg) to propofol in a recent meta-analysis was associated with the possibility of using up to half the doses of propofol, and thus resulted in an increase in the duration of seizure activity [49, 50]. Moreover, it reduced the maximum values to which the systolic blood pressure increased [51]. Kessler et al. [52], however, draws attention to the need for considerable caution in the routine addition of remifentanil to barbiturate anesthesia, as it does not affect the long-term remission and recurrence rates, and is associated with a higher risk of side effects, such as nausea, dizziness or headaches. According to the latest network meta-analysis, the use of remifentanil seems to be the best option in the prevention of myoclonus induced by etomidate, which may be of particular importance in patients with a high baseline concentration of potassium with the simultaneous use of succinylcholine, as both myoclonus and succinylcholine cause a strong shift of potassium ions outside the muscle cell [53].

Depth of anesthesia

Another aspect of anesthesia, apart from the type of anesthetic, is its depth itself, depending on the dose of the anesthetic used. Too deep anesthesia is associated with more difficult induction of an epileptic seizure, its worse morphology and duration [54, 55]. The single numerical parameter indicating the depth of anesthesia is the bispectral index (BIS), which transforms many EEG parameters into a numerical value from 0, which indicates the lack of electrical brain activity, to 100, i.e., full consciousness [56]. Typically, during other procedures requiring general anesthesia, the BIS value is between 40 and 60, however, in the case of ECT, it has been retrospectively demonstrated in a relatively large group of patients that the higher the BIS, i.e., the shallower the anesthesia, the better the seizure response [57]. Kranaster et al. [57] showed that with BIS 65, i.e., on the border of light anesthesia and deep sedation, the energy load necessary to induce an adequate epileptic seizure was almost three times lower than with BIS 60. It should be remembered that in the case of ketamine anesthesia, BIS monitoring is pointless due to the fact that ketamine induces dissociated anesthesia [58].

Muscle relaxants

The flow of electric charge is necessarily associated with the need to fully relax the patient's muscles. Although the type of myorelaxant used does not affect the effectiveness of the procedure as much as in the case of an anesthetic, one should remember about some specificity of ECT procedures. The agent of choice remains succinylcholine, which provides quick and short-term relaxation with a good safety profile. However, its depolarizing effect on the muscle plate is associated with certain limitations, e.g., it should not be used in the case of hyperkalemia, extensive burns, spinal, peripheral nerve and muscle injuries [59]. It is also a known risk factor for malignant hyperthermia [60]. Moreover, there are reports of prolonged apnea in patients with butyrylcholinesterase deficiency [61]. In all these situations, non-depolarizing agents, such as mivacurium or atracurium, turn out to be effective, although then the time of the procedure itself is significantly longer.

It was shown that the use of cisatracurium was associated with a lower increase in potassium concentration, longer duration of the epileptic seizure, faster return of spontaneous breathing, and lower postoperative tachycardia compared to succinylcholine [62]. A retrospective analysis of 500 cases indicates exceptional individual variability in susceptibility to succinylcholine [63]. In order to achieve adequate relaxation, it was necessary to use doses ranging from 0.29 mg/kg to even 2.1 mg/kg. The standard dose of 0.9 mg/kg body weight should therefore be used during the first treatment, and then individually adjusted to the patient during subsequent ECTs. Asztalos et al. [64] showed that extending the time from succinylcholine administration to charge flow by 30 seconds (up to 120 seconds) was associated with fewer necessary restimulations.

An interesting option seems to be to shorten the duration of the relaxation caused by rocuronium by using sugammadex, which is a modified gamma cyclodextrin molecule,

which ensures complete abolition of the relaxation caused by non-depolarizing drugs of steroid structure by their encapsulation into water-soluble guest-host complexes [65]. So far, the effective use of the rocuronium-sugammadex combination during ECT procedures in patients with Brugada syndrome, in cases of neuroleptic malignant syndrome, during hemodialysis and in pseudocholinesterase deficiency has been described [66–68]. In addition, the abolition of neuromuscular blockade with sugammadex was associated with a lower risk of headache and muscle pain after the procedure, as well as shorter reorientation time [69, 70]. In most countries, including Poland, due to the high costs associated with the use of sugammadex, its use for ECT procedures is significantly limited. A more available alternative to rocuronium and sugammadex may be the reversal of mivacurium-induced muscle block with intravenous administration of neostigmine at a dose of 0.5–2 mg. [71].

Recapitulation

Although ECT procedures are currently performed in accordance with the highest standards and are characterized by a high safety profile, the progress made in anesthesiology makes it possible to optimize their effectiveness and reduce potential side effects. Individual and personalized adaptation of the anesthesia protocol, choice of anesthetic and muscle relaxant, the depth of anesthesia itself, and finally the use of additional corrective drugs make ECT a much more acceptable form of treatment for severe mental disorders both for patients, their families and other physicians specialties.

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