The Trigeminocardiac Reflex in Electroconvulsive Therapy

Dear Sir:

In this commentary, we discuss bradycardia and asystole during electroconvulsive therapy (ECT), phenomena that all ECT practitioners are likely familiar with, but which perhaps deserve to be looked at from a different angle.

Acute poststimulus bradycardia and asystole are common during ECT. Incidence depends on electrode placement, stimulus train duration, pulse width, and baseline heart rate, as well as age, and possibly concomitant medication (eg, β-blockers).[1–6] Typically, this effect has been ascribed to activation of the vagus nuclei in the brainstem caused by the electrical stimulus itself,[7] which is subsequently counteracted by sympathetic activation caused by the seizure. This led to theoretical considerations that subconvulsive stimuli in ECT are particularly prone to lead to bradycardia because of a lack of subsequent sympathetic activation from a seizure. This hypothesis is supported by model calculations, suggesting current flow through the vagus nuclei during stimulation, which is thought to cause increased vagal tone.[8] However, it has been pointed out that the validity of such model calculations should be interpreted with caution and that they might not accurately reflect the situation in vivo.[9] The hypothesis of stimulation of vagus nuclei also leaves some unanswered questions: why would only the vagus nuclei in the brainstem be affected by the stimulus and why are there no clinical effects due to activation of the many other brainstem nuclei?

A very obvious site involved by stimulation during ECT is the trigeminal area, which is located directly beneath the right electrode in the d'Elia placement. It would certainly be of no surprise that a current flow of 900 mA and a frequency of typically 10 to 70 Hz lead to a massive irritation of the trigeminal nerve. For example, right unilateral stimulation sometimes leads to an impressive flush of the entire ipsilateral trigeminal area.[10] We therefore argue that activation of the trigeminal nerve might convey some of the cardiac effects observed during ECT.

The trigeminocardiac reflex (TCR) is a brainstem reflex that clinically leads to hypotension, bradycardia, apnea, and gastric hypermotility. It is considered the most powerful autonomic reflex in humans and other mammals.[11] A well-known and well-studied subtype of the TCR is the diving reflex, which is thought to be an evolutionary mechanism to improve acute oxygen savings and distribution during diving. Another form of the TCR is widely known to clinicians as the Aschner reflex, in which compression of the eyeballs results in a significant reduction in heart rate. While central activation of the TCR, for example, during neurosurgery, leads to bradycardia and hypotension, peripheral activation of the TCR leads to a coactivation of vagal and sympathetic nerves. Activation of sympathetic nerves results in vasoconstriction and associated hypertension, whereas activation of vagal nerves leads to bradycardia.[12]

This combination of poststimulation bradycardia or asystole and hypertension can also be observed during ECT. Furthermore, the Trigemino-Cardiac Reflex Examination Group identified hypercapnia, hypoxemia, light general anesthesia, young age, and a strong and/or long-lasting provoking stimulus as predisposing factors for the occurrence of the TCR.[12] This is in line with findings on asystole in the context of ECT, where nongeriatric age has also been found to be one predisposing factor.[13] Light general anesthesia and a strong provoking stimulus are further characteristics of ECT. Also, the studies by Nagler[1] and Stewart et al[2] impressively showed that both right unilateral and bilateral electrode placement resulted in more pronounced asystole and bradycardia than bifrontal stimulations. This difference could also be explained by greater stimulation of the TCR, because the trigeminal nerve is more directly stimulated by the electrode placement in right unilateral and bilateral stimulation. Lastly, TCR-induced gastric hypermotility could possibly offer an additional explanation for post-ECT nausea and vomiting.

Consideration of the TCR as the potential origin for cardiac effects of ECT is important because it might have clinical implications. For example, it could influence the choice of anesthetic used for ECT. Ketamine has been shown to block some of the cardioinhibitory effects of the TCR by inhibiting excitatory postsynaptic current peak amplitude and duration in cardioinhibitory vagal neurons in the brainstem.[12] Also, management of concomitant psychiatric medications during ECT might be affected. Citalopram has been shown to more than double the peak amplitude of the excitatory synaptic response in cardioinhibitory vagal neurons, an effect ascribed to serotonin and thus potentially affecting a wide range of psychiatric medications commonly used during ECT.[12] Furthermore, narcotics such as sufentanil and alfentanil, preoperative β-blockers, and calcium-channel blockers have all been described as triggers for intraoperative TCR.[14] This could have direct implications for medication management in the context of ECT. To our knowledge, no studies investigating the effects of ketamine and serotonin reuptake inhibitors on asystole and bradycardia during ECT have been published so far.

In addition, findings from ECT research might contribute to TCR research. The TCR has mainly been described in the context of neurosurgical procedures and less commonly other surgical procedures in the vicinity of the trigeminal nerve. However, it has been suggested that nonsurgical cases of TCR activation are underreported.[15] So far, hypotension, bradycardia, apnea, and gastric hypermotility have been attributed to the TCR.[16] Because lacrimation and hypersecretion also occur during ECT, the question arises whether these two phenomena are also attributable to the TCR. Also, bradycardia and asystole appear to be less prominent with restimulation.[17] It is possible that the TCR has a refractory period, which has not been reported so far.

In summary, the TCR provides an alternative explanation for poststimulus asystole. In addition to potentially providing a better explanation for this ECT adverse effect, this new perspective may also help to better identify and mitigate risk factors for cardiac arrhythmias in patients at risk.

Alexander Sartorius, MD
Department of Psychiatry and Psychotherapy
Central Institute of Mental Health
Medical Faculty Mannheim
Heidelberg University
Mannheim, Germany

Charles H. Kellner, MD
Department of Psychiatry and Behavioral Sciences
Medical University of South Carolina
Charleston, SC

Sebastian Karl, MD
Department of Psychiatry and Psychotherapy
Central Institute of Mental Health
Medical Faculty Mannheim
Heidelberg University
Mannheim, Germany
sebastian.karl@zi-mannheim.de

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