Cognitive Neuroscience of Neuroinfectious Diseases

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Когнитивная нейробиология нейроинфекционных заболеваний

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Abstract. Infectious diseases, particularly those involving viral pathogens, involve infiltration of CNS structures. Increasing suspicion of hypoxic-related neuronal infiltration has been documented in COVID-19. Increasingly effective treatments for hypoxia and prophylactic vaccinations with improved efficacy will result in greater survival rates of COVID-19 patients. The burden of COVID-19 disease impacts the employed adult population with the likelihood that lingering cognitive sequelae requires investigation and redress as the world assumes normality in the various work arenas. Whilst the effects of COVID-19 on cognitive functions and hence employability are strongly suspected, no systematic theoretical framework of the underlying neuropathological processes and pathways and approaches to assessment

have been offered. This abstract proposes Luria's Model of Neuropsychological Functioning (Luria, 1980) as a broad framework to investigate and document the neurocognitive effects of neuroinfectious diseases such as COVID-19. The authors acknowledge that, with increasing knowledge of the diverse symptom patterns associated with disease process underlying COVID-19, the framework of neurocognitive assessment will need to undergo refinement to provide a succinct synopsis of the cognitive capacity of survivors of this disease to inform best medical practices and the decisions facing other sectors such as employers.

Keywords: neuroinfectious disease; virus; COVID; Luria; neuropsychology; neuropathology

Аннотация. Инфекционные заболевания, особенно с участием вирусных патогенов, вызывают инфильтрацию структур ЦНС. Возникновение нейронной инфильтрации, связанной с гипоксией, документально подтверждено при COVID-19. Более эффективные методы лечения гипоксии и профилактические прививки приведут к увеличению выживаемости пациентов с COVID-19. Одним из последствий заболевания COVID-19 являются длительные когнитивные осложнения, требующие исследования и компенсирования, чтобы у людей трудоспособного возраста восстановились трудовые навыки. Несмотря на то что высока вероятность влияния COVID-19 на когнитивные функции и, следовательно, на трудоспособность, никакой систематической теоретической основы для определения нейропатологических процессов, а также подходов к оценке тяжести осложнений не было предложено. В этой публикации рассматривается модель нейропсихологического функционирования, разработанная А. Р. Лурия (1980), в качестве широкой основы для исследования и документирования нейрокогнитивных эффектов нейроинфекционных заболеваний, таких как COVID-19. Авторы признают, что с увеличением знаний о разнообразных симптомных паттернах, связанных с болезненным процессом, лежащим в основе COVID-19, структура нейрокогнитивной оценки должна будет подвергнуться уточнению. Это позволит предоставить краткий обзор когнитивных способностей излечившихся от данного заболевания и использовать новую информацию для разработки лучших медицинских практик и решений проблем, возникающих в других сферах, в том числе в трудовой деятельности.

Ключевые слова: нейроинфекционное заболевание; вирус; COVID; Лурия; нейропсихология; невропатология

Infectious diseases are part of world history (Morens & Fauci, 2020), and despite progress in medical management (Marchand-Senécal et al., 2020), transmissions appear to have sporadic surges and patterns of increase (Nath, 2015). These patterns are part of human history as viral pathogens continue to rise, mutate and infect human populations.

There are growing challenges in the identification and diagnoses of neuroinfectious diseases (Matthews et al., 2020). With respect to SARS-CoV-2, virus mutations have resulted in variants, posing challenges to the vaccination process.

Those populations who have significant medical morbidity or are considered vulnerable to infectious diseases have either succumbed to or, if they survive, are likely to be left with residual complaints that require redress. With the current COVID-19 pandemic,

neuronal injury has been implicated in those cases where hypoxia due to severe respiratory infection precipitated dependence on ventilation to support oxygenation of the brain (Chandra, Chakraborty, Pal, & Karmakar, 2020). Presence of intact CoV particles together with SARS-CoV-2 RNA in the olfactory mucosa, as well as in neuroanatomical areas receiving olfactory tract projections, may suggest the occurrence of SARS-CoV-2 neuroinvasion via axonal transport. However, given that the apparatus in which viral reproduction takes place is thought to be found in the neuronal somata, morphological detection of single viral particles in axons is very difficult, if possible at all, due to the low number of viral particles that are expected (Meinhardt et al., 2020). Further adding to this difficulty in visualizing SARS-CoV-2 within the CNS on a cellular level is the fact that the olfactory bulb is a relatively small CNS region with a limited number of neurons, which is evidenced by the small amount of viral RNA that was obtained in COVID-19 cases harboring SARS-CoV-2 PCR-positive olfactory bulbs.

Animal models have offered some insight into the patterns of COVID-related diseases. For example, enduring and sex-specific changes have been reported in rodent samples, with male rodents showing greater vulnerability to cognitive decline (Tchessalova & Tronson, 2020).

Direct SARS-CoV-2 viral invasion of the brain has been indicated such as in selected autopsy reports (Maiese et al., 2020). Continuous improvement in the treatment and attempts to mitigate infectious spread are hampered by second- and third-waves of COVID resurgence with more deaths but also survivors with residual complaints that require continuous assessment and management. The experience of a life-threatening disease with uncertain outcomes and requiring isolation from family and loved ones adds to the psychological burden of these patients, clouding the neurocognitive sequelae patterns that are emergent (Kontoangelos, Economou, & Papageorgiou, 2020). COVID-19 might be more visible in adults, but the health impact on infants and children is still uncertain and at this stage considered to be relatively low. Case studies of placental transfer of the SARS-CoV-2 virus have emerged, with the outcomes in ante- and post-natal stages in the developing infant inconsistently reported or documented (Hosier et al., 2020). The patterns of enduring cognitive decline will probably be domain-specific with memory and attention most vulnerable to the disease. Thus, a neurocognitive model that identifies neuronal pathways and centres, such as those proposed by Luria (1980), may provide a useful framework for studying, identifying and explaining short and long-term cognitive effects of COVID-19 and their effects on Activities-of Daily-Living.

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