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Effective Point of Diagnosis by Electrochemical Bio sensing Platforms

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Introduction

The World Health Organization identified a new zoonotic virus, responsible for causing the COVID-19. Since then, there has been a collaborative trend between the scientific community and industry. Multidisciplinary research networks try to understand the whole pathophysiology and its relationship with the different grades of severity presented by COVID-19. The scientific community has gathered all the data in the quickly developed vaccines that offer a protective effect for all variants of the virus and promote new diagnostic alternatives able to have a high standard of efficiency, added to shorter response analysis time and portability. The industry enters in the context of accelerating the path taken by science until obtaining the final product. In this review, we show the principal diagnostic methods developed during the COVID-19 pandemic. However, when we observe the diagnostic tools section of an efficient infection outbreak containment report and the features required for such tools, we could observe a highlight of electrochemical bio sensing platforms. Such devices present a high standard of analytical performance, are low-cost tools, easy to handle and interpret, and can be used in the most remote and low-resource regions. Therefore, probably, they are the ideal point-of-care diagnostic tools for pandemic scenarios.

A new infectious disease is often associated with the evolution of pathogens over time (genetic plasticity: mutation, re-assortment, and recombination). However, there are other conditions involved in the epidemic outbreaks, such as environmental (climate changes), ecological (deforestation), social (political and economic), and cultural factors (religion and eating habits). Around 75% of epidemic diseases have a zoonotic origin (pathogens jump from a vertebrate animal to a human). Transmission can occur by direct contact with the animal, vectors like fleas, ticks, and mosquitoes) or indirect contact, such as food and water contamination. Among the pathogens that managed to cross the species barrier (animal-human), about 44% have RNA viral origin. Although the response to epidemic outbreaks (restricted region) and natural disasters follow the same management cycle (mitigation, prevention, response, and recovery), the equivalent does not apply in pandemic cases. Pandemic outbreaks present cascading effects; they do not occur as single events in a short time but in several waves over a long period until the entire population is immunized (vaccine or herd effect). During that time, there are constant changes; each new pandemic wave is different, as we can see in the current COVID-19 pandemic. However, Health Agencies fight pandemics, taking into account each new stage change. The main ways used are information campaigns, social distancing, mask use, contact tracing, screening, quarantines, and rigorous mobility and travel restrictions. The gradual return of each activity is significant and, probably, different for each region since the complexity and non-linearity (frequent waves) observed in a pandemic state can make it difficult to return to "normal". Therefore, the population must have a robust bio surveillance system with rapid identification of microorganisms and efficient diagnostic tools. Thus, it would be possible to implement quick ways to measure biosafety and contain a possible epidemic outbreak.

Molecular and Immunological Tests

Some forms can be early detection of the disease, isolating and medicating the positive patient, tracking people who had contact with a positive patient, and promoting social distancing measures proportional to the risk of person to person transmission. The current pandemic has caused a "boom" in the diagnostic tools market. In 2020, regulatory agencies received hundreds of requests for clinical evaluation and formal approval of diagnostic tools for SARS-CoV-2. After a year of pandemic, such agencies have approved numerous molecular and immunological tests, but even so, many technical and operational problems are still reported. Success in controlling the COVID-19 pandemic is related both to the development of vaccines and mainly to the large-scale use of rapid and effective diagnostic tools. With the vaccines, it is possible to immunize the population, reducing cases of COVID-19. However, the satisfactory level of immunization is still unclear since further studies are needed to confirm the effect of protection against the COVID-19 variants. Thus, a rapid diagnostic remains the "key tool" for effective containment of the pandemic and has a high added value in reducing the damage caused by the future waves of COVID-19. This review describes the main features of the new HCoV, its origin, and possible factors related to the virus's emergence, known as severe acute respiratory coronavirus 2, responsible for the current COVID-19 pandemic and millions of deaths around the world. It provides information about the standard tests used for diagnosis, recommended by the World Health Organization (WHO) and the centre for Disease Control and Prevention (CDC), as well as the efforts of the scientific community to improve the performance of those standard assays. In addition, it emphasizes the need to develop new diagnostic tools for fast viruses' identification expanding the population's access to the early diagnosis, and avoiding virus dissemination. A promising candidate is electrochemical sensing platforms that offer benefits, including high sensitivity and selectivity, easy handling and interpretation (without specialized technicians), and easy execution in the field. Studies have shown that N and S structural proteins are closely related to CoVs pathogenicity. N protein plays an essential role both in viral genome packaging and viral transcription. In addition, researches have shown that N protein may also be associated with the host's immune response suppression, facilitating viral replication. S proteins have two subunits, with distinct functions. S1 binds to the cell surface receptor host through the receptor-binding domain (RBD) region present in this subunit. On the other hand, S2 mediates virus fusion with the host cell membrane.

Genome Evolution

Viruses with RNA genomes present high mutation rates due to peculiar features of RNA genomes not found in DNA genomes, such as high rates of replication, recombination, and segmentation in a short time. Thus, these features enable a rapid viral genome evolution, favouring variants emerging that can present new characteristics as virulence increases. The CoVs, RNA viruses, have innumerable mutations, mainly in the S protein, which could not be different. These mutations can favour the adaptation of this protein to various host receptor types, causing changes both in the tropism and in the pathogenicity of CoVs.

The first report about CoV isolation was made in the 1930 s in samples from chicken infected with avian bronchitis virus (IBV); ever since, many other zoonotic hosts were a source for virus isolation (birds, pigs, cows, dogs, cats, bats, and others). The animal-human species barrier was crossed in the mid-1960 s, when the first human coronavirus, HCoV-229E, was isolated from patients with common cold symptoms. Those viruses predominantly cause respiratory and intestinal infections and induce a wide range of clinical manifestations. Initially, pathogenicity classification categorized HCoVs as low pathogenic in humans and symptoms were associated primarily with mild and self-limiting upper respiratory tract infections, such as common cold. However, in the 2000 s, more specifically in 2002 and 2012, two new HCoV were isolated from patients with severe respiratory symptoms. These new viruses were officially named severe respiratory syndrome (SARS-CoV) and the Middle East respiratory syndrome (MERS-CoV). Phylogenetic studies showed that both belonged to the beta-CoV genera and originated from bats. Although CoVs have bats as their original host, they are not directly transmitted to humans, needing an intermediate host.