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Utilizing DNA Synthesis to Develop Fast Reactions to Pandemic and Emerging Pathogens

Shalini D*

Department of Biology, National Research Centre, Italy

Abstract

Emerging diseases and pandemic outbreaks pose an increasing threat to the global community's health and economic stability given how interconnected our globe is today. The current 2009 Influenza A pandemic, the SARS outbreak, and the persistent threat of international bioterrorism are proof of this. Fortunately, the biomedical community has been able to quickly produce sequence data, allowing for the quick identification of these pathogens. However, despite having sequencing data, it has taken a while for this information to be used to generate actionable treatments or useful experimental results. Thus, it is possible to quickly identify a pathogenic danger that has emerged or progressed into a pandemic; but, doing so in a way that turns this identification into a focused therapy or treatment that is quickly available has proven challenging. Public health depends on being ready for bioterrorist strikes and early detection of specific agents. Emergency rooms might have a significant impact in this area. The broad definition of bioterrorism includes not just catastrophic terrorism that results in high numbers of casualties, but also microevents that use low-tech yet nonetheless cause public unrest, disruption, disease, impairments, and death. It tries to undermine social and political order in addition to causing mortality and morbidity. The most effective protection against potential bioterrorist attacks seems to be preparation. In this essay, we want to raise awareness of biological agents and emphasise how crucial emergency rooms are to solving this public health issue.

Keywords: SARS; Pandemic; Biomedical

Introduction

The term "disease" refers to diseases that hinder normal tissue function. For instance, measles, atherosclerosis, and cystic fibrosis are all regarded as diseases. However, each of these diseases has essentially unique causes. A particular genotype that causes poor chloride ion transport across cell membranes and excessively thick mucus formation is the cause of cystic fibrosis (CF) [1]. Therefore, the term "genetic or metabolic disease" best describes CF. Because atherosclerosis often manifests as a problem later in life after cholesterol plaques have accumulated and partially clogged arteries, it may be regarded as an ageing disease that increases the risk of heart attacks and strokes. Measles, however, is an infectious disease since it is contracted by contact with an outside agent. Pathogens are microorganisms that can infect humans and cause disease [2]. It's crucial to remember that the majority of bacteria do not cause disease, even though they frequently attract the most attention. In fact, many likely offer some defence against dangerous microbes as a result of their ability to efficiently compete with them for resources, stopping them from proliferating.

A genuine pathogen is an infectious agent that may infect practically any host that is vulnerable and cause disease. Opportunistic infections are potentially contagious organisms that rarely result in illness in people with strong immune systems [3]. Opportunistic pathogens frequently afflict populations like the elderly (whose immune systems are deteriorating), cancer patients undergoing chemotherapy (which has a negative impact on the immune system), or those with AIDS or HIV positivity. Infection and disease are not the same thing. When a pathogen enters and starts to grow inside a host, an infection is the result. Only when tissue function is compromised as a result of a pathogen's invasion and development does disease occur. Our bodies have defence systems to ward against infection and, if those defences fall short, to stop disease from developing once infection has taken place. Despite being highly contagious and easily spreadable, some infectious agents are not particularly likely to result in disease. The polio virus is one illustration [4]. Most persons who come into touch with it are probably infected, but only 5 to 10% of those who are infected go on to develop a clinical illness. Other infectious agents are very virulent, but not terribly contagious. The majority of infections must infiltrate regions of the body where they are not ordinarily found, however others can grow near the site of first entry. By fusing to particular host cells, they accomplish this. While some pathogens, like viruses and some bacterial species, penetrate the host cells and proliferate there, others, like pathogens, such as those that cause cancer, multiply between host cells or within bodily fluids. Even though in rare circumstances the proliferation of pathogens may be sufficient to destroy tissue, damage is typically brought on by the pathogen's production of toxins or destructible enzymes [5]. For instance, Corynebacterium diphtheriae, the bacteria that causes diphtheria, only thrives on surfaces of the nose and throat. The circulatory system, however, spreads the toxin it creates to other tissues, harming the heart, liver, and nerve cells. A viral particle first binds to a particular host cell by protein receptors on its outer envelope, or capsid, during the basic process of infection and reproduction by a DNA virus. The viral genome is subsequently injected into the host cell, where it employs the enzymes of the host cell to copy its DNA, translate its messenger RNA into viral proteins, and replicate its DNA. The newly created viruses are then expelled from the host cell when the viral proteins and replicated DNA have been put together into full viral particles [6]. In a few instances, viral-derived enzymes break down the host cell membranes, destroying the cell and releasing fresh virus particles. Other times, new virus particles emerge from the cell through a budding process, weakening but not

***Corresponding author:** Shalini D, Department of Biology, National Research Centre, Italy, E-mail: shalini@rbiologyt.lleri.in

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eradicating the cell.

Pandemic Viral Outbreaks

Effective PCR and sequencing techniques to swiftly identify and define the pathogen have made it easier to decide whether an isolated viral outbreak could turn into a pandemic. These emerging pathogens have been identified, and the Center for Disease Control (CDC) or World Health Organization (WHO) can now decide if they pose a pandemic hazard thanks to the timely production of sequence data from affected patients. Based on the early infection rate, sequence data similarity, and molecular markers for the virulence factor, this conclusion has been reached. Consider the most recent pandemic of the 2009 H1N1 influenza A virus (2009 H1N1), which was discovered in Mexico and quickly spread to other nations. In addition to the influenza pandemics, a big emergent outbreak in 2002 that spread to various regions throughout the world was brought on by a coronavirus that was completely unrelated. This was the widely-publicized SARS virus, which started in the Chinese province of Guangdong before spreading to 37 other countries. Prior to Wang of the virus chip to identify SARS as a coronavirus, the precise viral cause of the disease was unknown. According to estimates, this virus caused 8,000 people to become morbid, with a 10% fatality rate as a result. Even though their genetic make-ups are very distinct, they both exhibit cross-transmission [7]. A wide variety of mammalian and avian hosts are susceptible to infection by these viruses.

Emerging Pathogens

In addition to the known pandemic dangers mentioned above, some emerging diseases that escape their existing niche and start to infect sizable human populations also pose a threat to the local and, potentially, global community. Previously, an emergent outbreak would only have affected a specific area of the world, but with the increase in international travel, these infections now have the potential to affect the health of the entire human race. Food-borne pathogen outbreaks, nosocomial epidemics, and bioterrorist agents like smallpox, which has been eradicated from the general population, are a few examples of these emerging infections. The Division of Emerging Infections and Surveillance Services of the Centers for Disease Control and Prevention (CDC) is currently responsible for monitoring emerging infections as they emerge in an effort to pinpoint causal agents and contain any outbreaks [8].

Economic Impact: Halting Pandemics Rapidly in order to Prevent Economic Hardship

Due to the shock of human casualties as well as the flight of wealth from emerging nations to "safe havens" like the US and the EU, the economic impact on the developing world would be significant. These startling figures highlight the necessity for quick, precise therapies, even if the hyper pandemic is an incredibly unusual occurrence that no one ever wishes to experience. The rise of antiviral-resistant strains shows that DNA synthesis must be harnessed in order to create targeted treatments that can take the place of existing antivirals. These DNA-based treatments might be tailored to specific sequences as they are discovered in the field, making the treatment adaptable.

Detection

After the 2001 US anthrax letter attack, it became clear that vital facilities needed to be identified and decontaminated. Since numerous and advanced detection and decontamination systems have been created and put into practise, a tremendous advancement in the detection, protection, and decontamination of biological warfare agents has evolved in the last ten years. In the event of an assault, a large number of individuals may be impacted quickly, and the healthcare system may experience major disarray [9]. The US Centers for Disease Control advise healthcare professionals to be familiar with warfare agents in order to avoid logistical issues and a lack of medications and resources, and in collaboration with governmental organisations, have implemented a "Bioterrorism Preparedness and Response Program" to detect such threats. Rapid and precise technologies must be created in order to unequivocally prove these agents' presence in various ways. A biothreat agent must be identified at extremely small concentrations. Additionally, it must to be capable of being found in different matrices. Additionally, it must to be portable, user-friendly, and effective in detecting a variety of danger agents. All of the available systems are unable to satisfy these requirements; hence the methodology that is used must be determined by the circumstances. It is difficult to create detection systems that can identify biological agents at high quantities, and because antigen- and antibody-based systems are insensitive, research is focused on creating nucleic acid-based sensors that are far more sensitive but require more complex processing.

Role of Emergency Department [10]

Emergency services and governmental public health departments may establish a secure communication channel in conjunction with health departments and public health officials to respond to outbreaks of bioterrorist occurrences. A health advisory network may be established and maintained to facilitate communication between medical staff, emergency room professionals, infection control personnel, and infectious disease personnel in hospitals. Additionally, meetings may be held on a regular basis to exchange information about developing coordinated defences against bioterrorist strikes. Local health authorities, particularly emergency services, should routinely review coordination difficulties with agencies that act in response and periodically assess their preparedness for a potential bioterrorist assault. The development of disaster preparedness and response programmes, including anti-bioterrorism initiatives, is necessary.

The Emergence of DNA Synthesis and Its Promise for Rapidly Available Treatments

The recently developed science of synthetic biology has shed light on the potential for producing therapeutic drugs against new hazards as they emerge and endanger communities or the entire planet. In particular, synthetic biology has been made possible by the scientific community's ability to create genetic material in the form of DNA without using a natural template. The ability to modify and quickly produce genetic material is now a reality, opening up a broad field of novel research and treatments. For example, pathogens with synthetically designed genomes that are attenuated could serve as vaccines. In essence, a researcher may now quickly transform digital sequencing data into genetic material that is relevant to biology. Currently, the cost of synthesis is approximately 39 cents per base. Because of the previous method of creating small molecule inhibitors of microbes, using synthetic DNA-based therapeutics will also be cost-effective. These compounds were previously created by chemical library screening for efficiency against a particular pathogen [11]. This is a resource-wasting, brute-force approach to drug development. Given the capacity to create genetic material, a more focused and particular strategy should be used. This means no longer are drugs developed by trial and error, but rather in a thoughtful and targeted manner.

SiRNA Delivery as an Antiviral

Making a platform for the distribution of RNAi to stop a virus

from infecting would be one use of DNA synthesis. When employed as a targeted therapy strategy, these particular RNAs might be quickly generated for the target pathogen. The spread of plant viruses has been successfully reduced using this technique. Additionally, studies in mammals have demonstrated effectiveness in vivo. Infected mice were able to restrict the replication of Hepatitis B specifically, and other studies have demonstrated that siRNAs can slow the proliferation of Herpes in neurons and other target tissues. The main obstacle still needs to be addressed, and that is how these RNA molecules are delivered. But once the delivery obstacle has been overcome, the development of nucleic acid synthesis should enable their quick, precise manufacture [12].

Recombinant Protein Vaccines

The chances for peptide- or recombinant protein-based vaccines may potentially be improved by the quick production of sequencing data from emerging infections. It is simple to envision how quickly generated sequence data may be used to create a tailored peptide or RP vaccination in response to an emerging threat. An emergent pathogen's antigenic or coding sequences can be quickly captured by DNA synthesis and converted into an immediately usable peptide vaccination. However, before the use of peptide- or RP-based vaccinations as anti-infectives is fully practicable, the current disadvantages of low immunogenicity of peptide vaccines, weak adjuvants, and/or the absence of appropriate carrier molecules will require further improvement. The peptides have recently been used in advancements. However, attempts have been made to use replication-deficient adenovirus vectors as potential HIV vaccines, with modest success in boosting anti-HIV immunity in nonhuman primates. The benefit of utilising viral vectors is that they strongly stimulate CD4+ and CD8+ T-cell responses to the target antigen [13]. The potential for preexisting immunity to the vector, which would impede vaccination, as well as a meagre humoral response to the "vaccinating" transgenes-which may be necessary for protection-are still problems with viral vector vaccines that need to be addressed. Therefore, just like the peptide vaccine strategy, these also need to be improved before viral vectors are a widely accessible system that can be used quickly against an emerging pathogen [14].

Discussion

Live-attenuated vaccine is currently one of the most effective therapies for infectious illnesses. It has effectively reduced morbidity and mortality over the world and eliminated some human infections. In the past, viruses were repeatedly passed through nonhuman cells to create live-attenuated vaccinations, which were then less harmful when they were reintroduced to human hosts. This tactic, as opposed to user-directed attenuation, depends on random mutations. Synthetic biologists have recently been recoding viral infections with synonymous codon-pairs to attenuate them. This research examined the poliovirus and influenza codon-pair bias. A virus's genome was changed in a way that artificially reduced the translation efficiency of the viral genome. Their genomes had large sections "recoded" using under-represented codon-pairs. This recoding included over 400 synonymous mutations at the nucleotide level, which ultimately changed the translation rate of the genome while maintaining the identity of the amino acids at the protein level. Combining the power of gene-design computer software with large-scale DNA synthesis allowed for the macro-scale modification of genetic material. In animal models, these artificially altered viruses were attenuated. This approach shows promise as a foundation for the creation of live-attenuated vaccines, according to the New England Journal of Medicine. This technology has the potential to be used to produce live-attenuated vaccines to protect against viral threats as they emerge because it depends on DNA synthesis and broadly applicable computer software. Due to the nature of bioterrorism threats, cooperation between a numbers of sectors is necessary. This includes organisations from the fields of intelligence, police, forensics, customs, and other law enforcement, who must work with public and animal health organisations as well as environmental and social science organisations. These organisations must coordinate their decision-making processes based on the sharing of knowledge and information. To evaluate the risks of not sharing information among organisations with the advantages of sharing information in order to both prevent terrorist attacks and improve the ability to respond quickly in the event that they do occur, one can conduct"information sharing risk-benefit analysis." Early warning is the focus of Work Package 3 of the EU project AniBioThreat. The best defence against infectious diseases is vaccination, thus policymakers must concentrate on vaccine production. The use of vaccines in biological warfare is still up for dispute in academia. The main difficult problem in vaccine development is the unknown nature of the threats. Although vaccinations for the Ebola, anthrax, and smallpox viruses appear to take precedence, a comprehensive immunisation policy that covers both military personnel and civilians is required.

Conclusion

In conclusion, the 2009 H1N1 pandemic influenza has shown that there is a real risk of a worldwide pandemic and, thankfully, this most recent outbreak was caused by a virus with lower virulence. The biomedical communities are now more aware than ever before, though, that pandemic outbreak containment methods still need to be further developed and improved. Included in these are quick, focused reactions that limit the spread of illness. According to this commentary, DNA synthesis-based therapies and techniques should be seriously considered as treatments. Targeted medicines that could be quickly developed and modified as the viral outbreak mutates are made possible by DNA synthesis. According to sources, we are ill-equipped to respond to a terrorist strike that uses biological weapons [15]. The medical community should inform the public and decision-makers about the threat, just as it was done in reaction to the nuclear threat. We must be ready to identify, define epidemiologically, detect, and respond to the use of biological weapons and the threat posed by emerging and reemerging illnesses in the long run. On the near horizon, we cannot delay the formulation and implementation of strategic measures for coping with civilian bioterrorism. As a result, the mainstay of the conflict against bioterrorism is the education and training of healthcare professionals, particularly emergency physicians.

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Conflict of Interest

The author has no known conflicts of interested associated with this paper.

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