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(REVIEW ARTICLE)

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A review on how exactly covid-19 vaccination works

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Abstract

The Coronavirus pandemic has taken the world by storm, covering the entire year of 2020. In order to put an end to the pandemic many organizations around the world are racing to find a safe and effective vaccine. Today, newer technology of nucleic acid vaccine has been use to create a novel vaccine for novel coronavirus. Many countries like the United States of America, United Kingdom and even Russia and China have successfully developed approved vaccines. But there remains a doubt of uncertainty among people regarding how fast this vaccine was created when compared to others which have taken years. This review aims to highlight and summarize the ongoing process and development in making Covid vaccines.

Keywords: Coronavirus; Vaccination; Mutation; Heard immunity; mRNA; Adenovirus; Vectors; Efficacy; COVAX

1. Introduction

The Covid-19 pandemic has become a landmark of the years 2019 and 2020 and probably even the 21st century. As we race to find a cure to this deadly viral disease, many questions arise along the way. For it will be the first vaccine to be developed in matter of months and one of among the few against an RNA virus which is susceptible to frequent mutations. If the vaccine is successful, then it is possible to develop a vaccine against the HIV virus which cause AIDS and maybe even the Rhinovirus causing common cold.

1.1. Background of pathogen-SARS-CoV-2

The nCovid-19 is caused by SARS-CoV-2 virus which belongs to family *Coronaviridae* in the order *Nidovirales* with its genome as ssRNA [1,2]. So far, out of 100 strains of coronavirus,7 of them have been identified which are known to infect humans. Three of which viz. SARS-1, MERS and the recent SARS-CoV-2 have caused fatal respiratory infection in humans while the other four only lead to common cold[3].

The new variant of SARS-CoV-2, first reported by Britain is called VUI-202012/01 (the first "Variant Under Investigation" in December 2020) [4]. It has undergone 17 set of mutation and makes it 70% more transmissible [4].

1.2. Mutations

Mutation such as these happen to all living organism. But being an RNA virus makes the rate faster. As a result, the HIV virus mutates at a rate of $(4.1 \pm 1.7) \times 10^{-3}$ per base per cell, causing it bypass host immune system [5]. Thus, making it increasingly difficult to tract its changes and make suitable vaccine. Although, antiviral drugs fairly keep the viral load suppressed inside the body. Similarly, the Rhinoviruses has a mutation rate of 10^{-3} to 10^{-5} mutations per base per replication event [6]. The same can be applied for influenza virus causing the flu.

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But the RNA-dependent RNA polymerase (RdRp) which is the main enzyme for viral genome replication has a characteristic feature of proofreading in SARS-CoV-2 [7]. Therefore, making its rate of mutation appreciably less when compared to other ssRNA viruses. Hence making it possible to find its vaccine.

The coronavirus and influenza virus share much in common. Studies show that influenza virus undergo broadly two types of mutation; Antigenic Drift and Antigenic Shift. But due to four time slower mutation rate of coronavirus than the influenza virus, it has not yet undergone antigenic drift. This provides longer immunity from a vaccine than the flu vaccine which is taken every six months[19].

1.3. Structure of Coronavirus

When producing a vaccine, researches mainly focus only on one specific components of the pathogen that the immunity has to develop against. With experience from previous pandemics such as SARS-CoV-1 and MERS, the only component to be identified here for SARS-CoV-2 vaccine is the characteristic spike protein(S- protein). Show in Figure 1.

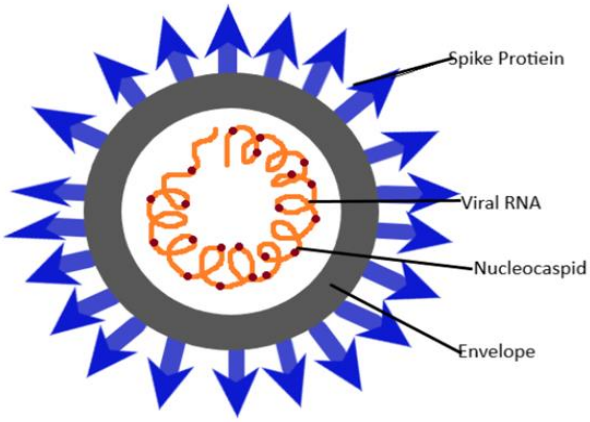

Figure 1 The figure shows structure of coronavirus.

The S-protein of virus is used in binding to ACE-2(angiotensin converting enzyme-2) receptor found on lung mucosa and GI tract. By blocking this protein through human body's antibodies,t virus can no longer infect the human cells. Thus giving protection against coronavirus.

2. Vaccination

2.1. How Vaccination works

Vaccines are infusion of artificial substance that prepare the body against deadly pathogens. Therefore, when it actually encounters the pathogen the infection produced are much milder and restores health faster.

2.2. Types of Vaccines

2.2.1. Whole virus

- Live attenuated virus using weakened whole Covid virus
- Inactivated virus[8]

2.2.2. Vector based vaccine-adenovirus

The use of human adenoviruses as vectors is safe as these viruses simply cause the common cold and successful treatments are available if infection is caused by the adenovirus. [12]

Example; Oxford AstraZeneca and Sputnik-V [10]

2.2.3. Protein subunit vaccine

The protein subunits of virus, usually the main spike proteins are injected into the body. But since the immune system cannot recognize them effectively, adjuvants are used.

2.2.4. Genetic vaccine

mRNA vaccine **–**latest and very new technique

- highest efficacy and efficiency rate
- Major problem in storage condition;
- The mRNA is prone to degradation at room temperature. Moderna's vaccine is stored at -20 degree Celsius (-4 degrees Fahrenheit), or at refrigerator temperatures for up to 30 days, while the Pfizer vaccine has to be stored at an ultra-cold temperature of -75˚C (-103˚F), and used within five days once refrigerated at higher temperatures[15].

DNA vaccines

Deoxy ribose nucleic acid vaccine using gene gun technology. But it still requires much development.

2.3. Organizations

2.3.1. Russia

The Russians organization Gamaleya Research Institute of Epidemiology and Microbiology developed Gam-COVID-Vac trade-named or commonly called Sputnik V registered on 11 August 2020 by the Russian Ministry of Health[15]. It was the first vaccine in the world to be approved for public distribution by the Russian Government [13]. It is a vector based human adenovirus vaccine. Here, two different types of adenovirus vectors (rAd26 and rAd5) were used for the first and second vaccination enabling the boosting effect of the vaccine. Efficacy of the vaccine is said to be about 91% to 100% in severe Covid cases [12]

The vaccine was financed by Russian Direct Investment Fund (RDIF) for the production of the Sputnik V, on the basis of production capacities of its portfolio companies, R-Pharm and Binnopharm, a part of the Alium Group [10,12].

2.3.2. China

The companies that developed the Chinese vaccines are; CanSino Biologics, Sinovac Biotech and Sinopharm. China approved its first COVID-19 vaccine for distribution Thursday December 31 developed by Sinopharm. The Vaccine has shown 86% efficacy, as reported by the United Arab Emirates Health Ministry, one of the countries where phase 3 trial was conducted[15].But according to the developer, the vaccine showed 79.34 per cent efficacy based on an interim analysis of late-stage clinical trials[16].

2.3.3. America (USA)

- Moderna and Inovio Pharmaceuticals-- mRNA-1273
- Pfizer–BioNTech vaccine-BNT162b2-In Europe, BioNTech, a German biotechnology company, developed a candidate it would later share with pharmaceutical giant Pfizer.
- Type: both are lab made messenger RNA (mRNA)[9]
- Efficacy is around 95% for both.[25]

2.3.4. United Kingdom

- Oxford/AstraZeneca vaccine
- Type; Inactivated adenovirus vector.
- the University of Oxford, an academic group created a vaccine that eventually attracted another Big Pharma partner, AstraZeneca[9]

2.3.5. India

COVAXIN™ is a COVID-19 inactivated virus type vaccine manufactured by Bharat Biotech in collaboration with the Indian Council of Medical Research (ICMR) - National Institute of Virology (NIV). The DCGI approved the vaccine for Phase I & II Human Clinical Trials on July, 2020. Bharat Biotech received DCGI approval for Phase 3 clinical trials across

India[11].Serum Institute of India has partnered with AstraZeneca and Oxford University to supply AZD 1222 vaccine for supply of vaccine to India[17].

2.3.6. COVAX

Coordinated by Gavi, the Vaccine Alliance, the Coalition for Epidemic Preparedness Innovations (CEPI) and the WHO. COVAX acts as a platform that supports research, development and manufacturing of authentic and secure COVID-19 vaccine candidates, and negotiate their pricing. The main goal of this organization is to provide all participating countries regardless of income levels equitable access to these vaccines [24].

3. Phases of vaccine development [17, 18]

3.1. Preclinical trials

Done in suitable animals or human cells in vitro. It determines the working of vaccine and takes the longest time in vaccine trial process.

Includes;

- PittCoVacc-Recombinant protein subunit vaccine; University of Pittsburgh.

3.2. Clinical Studies

All the clinical phases of trial consist of human volunteers with vaccine administration to one group and placebo control of other. This set up is done to compare and study the effect of vaccine in administered vs placebo volunteers.

3.2.1. Phase 1

Vaccines are given to small group of human volunteers limited to about 10 to 50 in number. It determines the safety of vaccine and may take few months.

Includes;

- COVI-VAC- Intranasal vaccine- Codagenix; Serum Institute of India

3.2.2. Phase 2

Vaccine is administered to medium group of individuals consisting of several hundred volunteers of various age groups. It determines the working and may take few months to years.

Includes;

- Protein subunit vaccine- Sanofi and GlaxoSmithKlein

3.2.3. Phase 3

Vaccine administered to large size group including thousands of volunteers of diverse background in age, sex, race and ethnicity. It determines its effectiveness which usually takes years to complete.

Includes;

- JNJ-78436735-Adenovirus- Johnson & Johnson
- Convidicea-Adenovirus Type 5 Vector- CanSino Biologics Inc.

3.3. Approved Vaccines

The data is obtained from phase 2 and phase 3 trials is analyzed and evaluated by the authorities which then get their approval for licensing and further manufacturing and distribution to the public.

Includes;

- mRNA-1273-mRNA based-Moderna
- BNT162b2 –mRNA-Pfizer-
- Sinophram -inactivated
- AZD 1222-inactivated adenovirus vector vaccine- Oxford AstraZeneca
- Covaxin-inactivated virus- Bharat Biotech
- Sputnik-V-vector based adenovirus-Gamaleya Research Institute of epidemiology and microbiolgy

3.3.1. Due to time constrain and the need and demand for a faster vaccine,

- Simultaneous production of large doses of vaccine along with phase 3 trials
- Overlapping of phase
- Challenge trials (still issue of safety concerns)

3.4. Side Effect of Vaccines

The focus is mainly on Pfizer and Moderna as these two have been approved all around the world.

3.4.1. Pfizer vaccine

Safety monitoring of Pfizer vaccine will continue for 2 years after administration of the second dose [20].

3.4.2. Adverse effect

- 4 cases of Bell's palsy were observed but these are number are same for chances of occurrence in normal condition without vaccine administration.
- Allergic reaction equivalent to anaphylactic reaction observed in healthcare workers after administration of vaccine
- No deaths were reported by the investigators to be related to the vaccine or placebo. No Covid-19–associated deaths were observed.

3.4.3. Moderna [21]

- pain at the injection
- fatigue
- headache
- fever and chills
- nausea
- myalgia

3.5. Who will get the vaccine first?

The first few doses of vaccine are being prioritized for frontline worker including medical and paramedical workers and those in vulnerable groups such as the elderly, or people living in crowded settings, and individuals with multiple existing conditions, such as serious heart diseases or diabetes. Workers in essential industries, such as in public transport or the jobs requiring them to meet large number of people such as prisons are also given priority[26].

4. Herd Immunity-a brief concept

It is referred to as "the resistance of a group against the attack of a disease because large proportion of its members being immune to it which decreases the likelihood of an affected individual transmitting it to other individuals" [22]. This indicates that is not necessary for a given population to be 100% vaccinated. Those at high risk or most vulnerable, if vaccinated reduces the transmission rate of infection. This also reduces the chance of spreading the disease from an affected individual to susceptible individual. Thereby effectively reducing the efficiency of microbe to survive, especially those which depend to person to person transmission. Therefore, it is easily controlled and disappears at some level of vaccine coverage over a period of time [23].

5. Conclusion

To conclude, vaccination is necessary to tackle the spread of pandemic and save the life of millions around the globe. Thanks to the new innovation in technology, we have been able to dive deep into the very core of virus and find a weak spot in its structure. But we have to keep in mind that not all the people on earth may get or require vaccine. Hence the new coronavirus norms have to be followed until the virus has disappeared completely.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares no conflicts of interest

References

[1] Enjuanes L, Almazán F, Sola I, Zuñiga S. Biochemical Aspects of Coronavirus Replication and Virus-Host Interaction. Annual Review of Microbiology. 2006; 60(1): 211-230.

[2] Perlman S, Netland J. Coronaviruses post-SARS: update on replication and pathogenesis. Nature Reviews Microbiology. 2009; 7(6): 439-450.

[3] Myint S. Human Coronavirus Infections. The Coronaviridae. 1995; 389-401.

[4] Wise J. Covid-19: New coronavirus variant is identified in UK. BMJ. 2020.

[5] Cuevas JM, Geller R, Garijo R, López-Aldeguer J, Sanjuán R. Extremely high mutation rate of HIV-1 in vivo. PLoS Biol. 16 Sep 2015; 13(9).

[6] Lewis-Rogers N, Seger J, Adler F. Human Rhinovirus Diversity and Evolution: How Strange the Change from Major to Minor. Journal of Virology. 2017; 91(7).

[7] Pachetti M, Marini B, Benedetti F, Giudici F, Mauro E, Storici P, Masciovecchio C, Angeletti S, Ciccozzi M, Gallo RC, Zella D. Emerging SARS-CoV-2 mutation hot spots include a novel RNA-dependent-RNA polymerase variant. Journal of Translational Medicine. Dec 2020; 18: 1-9.

[8] Xia S, Duan K, Zhang Y, Zhao D, Zhang H, Xie Z et al. Effect of an Inactivated Vaccine Against SARS-CoV-2 on Safety and Immunogenicity Outcomes. JAMA. 2020; 324(10): 951.

[9] Cohen J. Shots of hope [Internet]. Science. 2021.

[10] Burki T. The Russian vaccine for COVID-19. The Lancet Respiratory Medicine. 2020; 8(11).

[11] COVAXIN - India's First Indigenous Covid-19 Vaccine | Bharat Biotech [Internet]. Bharatbiotech.com. 2021.

[12] About Vaccine | Official website vaccine against COVID-19 Sputnik V. [Internet]. Sputnikvaccine.com. 2021.

[13] Cohen J. Russia’s approval of a COVID-19 vaccine is less than meets the press release [Internet]. Science | AAAS. 2021.

[14] Mahase E. Covid-19: Russia approves vaccine without large scale testing or published results. BMJ. 2020; 370: m3205.

[15] Salem M, Xiong Y. China's Sinopharm vaccine has 86% efficacy against Covid-19, says UAE [Internet]. CNN. 2021.

[16] Different efficacy data for Sinopharm COVID-19 vaccine 'real and valid': Media [Internet]. CNA. 2021.

[17] Sempowski G, Saunders K, Acharya P, Wiehe K, Haynes B. Pandemic Preparedness: Developing Vaccines and Therapeutic Antibodies For COVID-19. Cell. 2020; 181(7): 1458-1463.

[18] COVID-19 vaccine tracker [Internet]. Raps.org. 2021.

[19] How Do Viruses Mutate and What it Means for a Vaccine? | Breakthroughs [Internet]. Breakthroughs.com. 2021.

[20] Polack F, Thomas S, Kitchin N, Absalon J, Gurtman A, Lockhart S et al. Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine. New England Journal of Medicine. 2020; 383(27): 2603-2615.

[21] Baden L, El Sahly H, Essink B, Kotloff K, Frey S, Novak R et al. Efficacy and Safety of the mRNA-1273 SARS-CoV-2 Vaccine. New England Journal of Medicine. 2020.

[22] Saunders WB. Dorland's Illustrated Medical Dictionary. 28th Edn. Philadelphia: 1994; 812.

[23] John T, Samuel R. Herd immunity and herd effect: new insights and definitions. European Journal of Epidemiology. 2000; 16(7): 601-606.

[24] COVAX explained [Internet]. Gavi.org. 2021.

[25] Mahase E. Covid-19: Moderna vaccine is nearly 95% effective, trial involving high risk and elderly people shows. BMJ. 2020; 371: m4471.

[26] Subbaraman N. Who gets a COVID vaccine first? Access plans are taking shape. Nature. 24 Sep 2020; 585(7826): 492-3.