

IgG[4]. Moreover, antigens-specific recombinant V_HH, intravenously injected into tumor-bearing transgenic mice, were shown to penetrate and bind the deep-tissue located target antigens within two hours, and were retained in tissues for more than eight hours after administration[5]. This rapid tissue-ingress of intravenously injected V_HH has obvious potential for the treatment of viral infections.

Studies have shown that camel's immune system is a much stronger immune system than human, and its milk is adequate and effective among the other ruminant milk against microorganisms including *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhimurium*, and rotaviruses[9]. Camel milk has its unique nutritional composition and is rich in minerals, vitamins, low sugar and cholesterol and has a significant antioxidant effect[9,10]. In addition to the secretory IgA and IgM, as well as the small IgG antibodies, camel milk also possesses numerous non-antibody components such as lysozyme, lactoperoxidase and lactoferrin among others, with their scientifically proven effective antimicrobial activity, especially antiviral activity[9,10].

Currently, there is no cure for COVID-19 and attempts to produce a preventive vaccine against the virus are on the way. Therefore, we predict that using camelid to generate antibodies including the "V_HH" will potentially and selectively inhibit and neutralise SARS-CoV-2. This strategy involved efficacy *in vitro* evaluation of the generated anti SARS-CoV-2 camel antibodies, using standard scientific methods, and *in vivo* clinical trials study phase as outlined in Figure 1.

The neutralizing antibodies in the milk of immunised camels will give passive immunity to those with COVID-19 as a treatment or even can be given as a mean of prophylaxis to prevent those at risk of SARS-CoV-2 infection. Milk obtained from the immunized camels, after sterilisation, can be given to the patient infected with SARS-CoV-2, three times a day (300 mL) for three to five days (depending on the patient clinical complications) for the complete neutralisation of the virus in the same manner to that of the SQU-patent[6]. People at risk of infection, such as elderly people, patients with other serious medical complications and healthcare workers could be the initial target for such treatment. In addition to this new

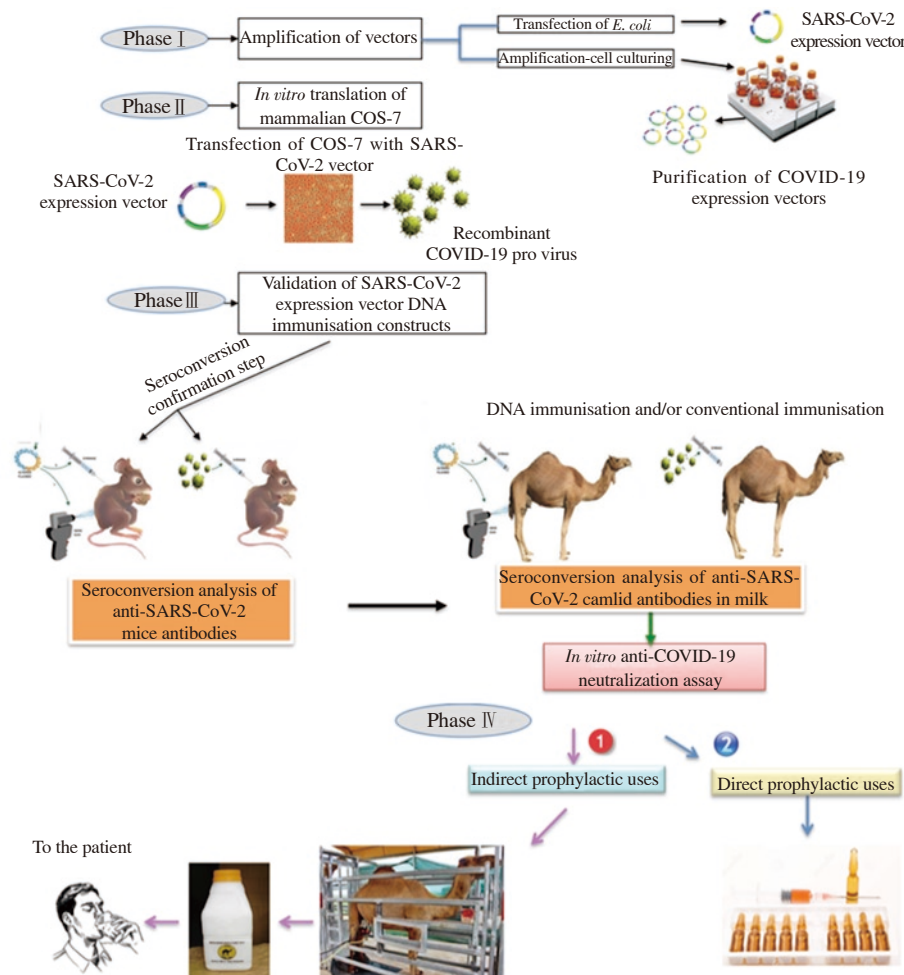


Figure 1. An outline schematic diagram showing the main phases of the strategy. The strategy consists of three main phases (I, II & III) and a clinical trial phase (IV). The three phases are: vector amplification; *in vitro*-translation of mammalian COS-7; and validation of the SARS-CoV-2 expression vector for DNA immunisation. The three phases involve standard scientific methods, both *in vitro* and *in vivo*, for raising antisera in animals and standard tests to confirm the production of the antisera. Anti SARS-CoV-2 camel antibodies efficacy must be confirmed *in vitro* as well as its safety prior it's used in the clinical trials. Ethical clearance must be obtained from the relevant authorised bodies prior to conducting this proposed strategy.

SARS-CoV-2 proposed treatment strategy, patients may also get the benefit of taking other immuno-stimulants, under medical care to enhance their own natural immunity against COVID-19.

Moreover, the strategy involves the isolation and purification of the raised antisera against SARS-CoV-2 and the utilization of these unique neutralizing antibodies, after carefully disinfecting any residues of viruses and other microbes by standard sterilisation methods. Once its efficacy and safety is confirmed, the purified antisera against SARS-CoV-2 can be transfused directly to the blood stream of the infected patient. This is in the same manner where current anti-snake venoms are generated and used.

Camels stock is available all over the world and can be used as mobile live factories to synthesise and produce these amazing neutralizing antibodies to treat COVID-19. We strongly believe that, camel milk with camel SARS-CoV-2-antisera, can be made safe and would be available and affordable worldwide to all in need. The method to generate these safe-neutralizing antibodies can be developed and used under careful control of health authorities and according to international standards, similar to those being currently used for the anti-snake venoms production. Such a novel treatment/prevention proposed strategy must be first tested both *in vitro* and *in vivo* and then confirmed in clinical trials, as per international standards and ethics before being made available to all in need. We believe, if such a strategy is known to the international scientific community, the time needed to test and confirm its efficacy will be very much shortened.

As an initiative to help humanity at this very critical time, we invite and encourage all researchers, research laboratories and research institutions all over the world to test and confirm the proposed strategy, of using lactating female camels as live factories to synthesise the desired antibodies, as a mean not only to prevent SARS-CoV-2 infection and to help in stopping COVID-19 pandemic, but also to confirm the use of this strategy against other viral and microbial infections.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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Authors' contributions

S.S.H. and A.A.A. equally contributed to the conception, design of the work, data analysis and interpretation, drafting and critical revision of the manuscript and final approval of the version to be published. S.S.H. contributed significantly to data collection and experimental field work.

References

- [1] World Health Organization. *Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV)*. 2020. [Online]. Available from: [https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)) [Accessed on 18th Feb 2020].
- [2] Wu F, Zhao S, Yu B, Chen YM, Wang W, Song ZG, et al. A new coronavirus associated with human respiratory disease in China. *Nature* 2020; **579**: 265-269.
- [3] Memish ZA, Cotton M, Meyer B, Watson SJ, Alshafi AJ, Al Rabeeah AA, et al. Human infection with MERS coronavirus after exposure to infected camels. *Emerg Infect Dis* 2014; **20**(6): 1012-1015.
- [4] Hamers-Casterman C, Atarouch T, Muyldermans S, Bendolman N, Hamers R. Naturally occurring antibodies devoid of light chains. *Nature* 1993; **363**: 446-448.
- [5] Cortez-Retamozo V, Lauwereys M, Hassanzadeh Gh G, Gobert M, Conrath K, Muyldermans S, et al. Efficient tumor targeting by single-domain antibody fragments of camels. *Int J Cancer* 2002; **98**(3): 456-462.
- [6] Hasson SS, Al-Jabri AA. *Therapeutic composition. US10336817B2, filed by Sultan Qaboos University. Being granted by the US Patent Office in 2016 (Priority to ZA16/7084 2016-10-14)*. [Online]. Available from: <https://patents.google.com/patent/US10336817B2/en?q=camel+hiv&oq=camel+hiv> [Accessed on 8th April 2020].
- [7] Jasion VS, Burnett BP. Survival and digestibility of orally-administered immunoglobulin preparations containing IgG through the gastrointestinal tract in humans. *Nutr J* 2015; **14**: 22.
- [8] Herrera MG, Leon A, Segura F, Meneses B, Lomonte J, Philippe JP, et al. Factors associated with adverse reactions induced by caprylic acid-fractionated whole IgG preparations: Comparison between horse, sheep and camel IgGs. *Toxicon* 2005; **46**: 775-781.
- [9] el Agamy EI, Ruppner R, Ismail A, Champagne CP, Assaf R. Antibacterial and antiviral activity of camel milk protective proteins. *J Dairy Res* 1992; **59**(2): 169-175.
- [10] Shamsia SM. Nutritional and therapeutic properties of camel and human milks. *Int J Genet Mol Biol* 2009; **1**: 52-58.