Int J Physiol Pathophysiol Pharmacol 2021;13(5):148-151
www.ijppp.org /ISSN:1944-8171/IJPPP0136828

Original Article

Change of blood viscosity after COVID-19 vaccination: estimation for persons with underlying metabolic syndrome

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Received June 28, 2021; Accepted October 11, 2021; Epub October 15, 2021; Published October 30, 2021

Abstract: The COVID-19 vaccine is a new vaccine aiming at control of COVID-19 pandemic. This new vaccine is useful for pandemic management, however, an important consideration is on its safety. Thrombosis is a problem might occur after COVID-19 vaccination and the increased blood viscosity is a pathomechanism. Here, the authors estimate on blood viscosity change after COVID-19 vaccination for vaccine recipient with underlying metabolic syndrome. Based on mathematical modelling and simulating technique, the authors estimate the change of blood viscosity after COVID-19 vaccination for persons with underlying metabolic syndrome. According to the estimation, blood viscosity in a healthy person is estimated 2.7 times higher than the normal value while blood viscosity in person with the underlying metabolic syndrome is estimated 2.99 times higher than the normal value. Based on this preliminary report, a more increased blood viscosity level is detected in vaccine recipients with the underlying metabolic syndrome. Monitoring of the blood viscosity problem among a vaccine recipient who has metabolic syndrome is recommended.

Keywords: COVID-19, blood, viscosity

Introduction

Coronavirus Disease 2019 (COVID-19) pandemic is the important global public health emergency. This new infection is caused by the novel Severe Acute Respiratory Syndrome-Coronavirus-2 (SARS CoV2) virus. This new infection is an acute respiratory illness, which might cause severe respiratory dysfunction and death [1, 2]. Prevention of infection is necessary. For a successful prevention, an effective preventive tool is needed.

The COVID-19 vaccine is a new vaccine that has just been in use for a few months. It is aimed at a successful control of COVID-19 pandemic. This new vaccine is useful for pandemic management and the efficacy of the vaccine is usually claimed [3, 4]. However, an important consideration is on its safety, an induction of an unwanted side effect. Clot formation and thrombosis are clinical problems that might occur after COVID-19 vaccination and the increased blood viscosity is a pathological mechanism [5].

Basically, blood viscosity is determined by blood solute and solvent. In plasma, the protein and biochemical components are important determinants for blood viscosity level. In a recent report, there is an increased blood viscosity after COVID-19 vaccination due to the increased level of immunoglobulin in blood [5]. An important consideration is on the impact of underlying medical problems of vaccine recipients. A common medical problem worldwide is metabolic syndrome. In a case with metabolic syndrome, a high blood sugar and lipid (diabetes and hyperlipidemia) is common. Effect on blood viscosity is possible [6, 7]. Here, the authors estimate on blood viscosity change after COVID-19 vaccination for vaccine recipient with underlying metabolic syndrome.

Materials and methods

This work is a mathematical model-based study. The authors estimate on blood viscosity change after COVID-19 vaccination for vaccine recipient with underlying metabolic syndrome. The inclusion groups for simulation are healthy

Table 1. The increased blood viscosity level in healthy COVID-19 vaccine recipient and recipient with underlying metabolic syndrome

Groups	Increased blood viscosity	
	%	Times
healthy COVID-19 vaccine recipient	179.1	2.79
vaccine recipient with underlying metabolic syndrome	223.1	2.99

COVID-19 vaccine recipient and COVID-19 vaccine recipient with metabolic syndrome. Cases of the other additional medical disorders were excluded. The simulating is performed for comparing cases with metabolic syndrome and health control. The conceptual framework for clinical modeling and study technique is based on previous publication [5]. The referenced formula for calculating blood viscosity level is based on the model described by Duyuler et al. [6]. This index for calculating is the same as that described in a previous publication on blood viscosity of COVID-19 patient [7]. The index for calculating the blood viscosity level is according to Duyuler's method and formula for calculation of blood viscosity index is "(1.89 × HCT) + 3.76 (TP-78.42)", where HCT is hematocrit in %, TP is total protein concentration in g/L, and the outcome is the whole blood viscosity in centipoise (cp) [8].

Primary data for modeling include (a) blood viscosity among normal, healthy person prior to COVID-19 vaccination, which is equal to 1.5 cp), (b) blood viscosity in persons with metabolic syndrome and c) increased interval of blood viscosity after COVID-19 vaccination, which is equal to 24 cp [5]. Regarding metabolic syndrome, the two main factors, glucose and lipid effect, due to diabetes and hyperlipidemia, are considered in this study. A primary assumption for the model is no effect of other factors affecting blood viscosity.

For calculation, increased blood viscosity level is estimated in term of percentage and times comparing to background value in normal healthy person. Hence, the value of increased blood viscosity for healthy COVID-19 vaccine recipient and recipient with the underlying metabolic syndrome are described as following equations: a) for healthy COVID-19 vaccine recipient: "(Post vaccine elevated level-Pre vaccine level in healthy person)/Pre vaccine level in a healthy person"; b) for recipient with the underlying metabolic syndrome: "(Post vaccine elevated level-Increased level due to high blood glucose and lipid-Pre vaccine level in a healthy person)/Pre vaccine level in healthy person".

The post vaccine elevated level is equal to +2.4 cp and pre vaccine level in a healthy person or normal reference value is equal to 1.34 cp as earlier mentioned [5, 8, 9]. Regarding pre-vaccine background due to diabetes and hyperlipidemia, the values are 1.5 and 1.44 cp, respectively [9, 10].

The protocol of this work was approved by the local ethical committee (No. SMA2-25/2021). This work is a retrospective study and it is a mathematical modeling study, which involves no human or animal subjects, hence, the informed consent is not applicable.

Results

According to the clinical modelling, the increased blood viscosity level in healthy COVID-19 vaccine recipient and recipient with underlying metabolic syndrome is presented in **Table 1**. Increased blood viscosity in healthy person is estimated 2.7 times higher than the normal value while increased blood viscosity in person with underlying metabolic syndrome is estimated 2.99 times higher than the normal value. Increased level in both healthy and metabolic syndrome recipient does not reach hyperviscosity level.

Discussion

An elevated level of acute phase reactants after vaccination is the cause of blood viscosity change. In a healthy person, the blood viscosity change after COVID-19 vaccination will cause no problem. If there is an interruption of normal physiology, the clot formation and thrombosis might be complications [11]. Blood viscosity plays an important role, according to Virchow triad, in thrombosis formation [12].

Of several possible mechanisms, a hyperviscosity after vaccination is an important mechanism [4]. Physiologically, a normal COVID-19

vaccine recipient will have +2.4 cp increased blood viscosity level after vaccination [4]. There might be a different level of elevated of blood viscosity if there is an underlying medical problem. Any condition with an increased blood concentration, either high blood solute or decreed plasma volume, can result in an increased blood viscosity.

The vaccine induced hyperviscosity is a possible underlying mechanism for many adverse reactions of COVID-19 vaccination [13-17]. The problem of blood viscosity becomes an important consideration for a vaccine recipient who has an underlying medical problem. Of several medical problems, metabolic syndrome is a common clinical syndrome. The patient with this syndrome has a high blood glucose and lipid, which is a condition with a high solute element. Hence, there is a higher blood viscosity in a person with metabolic syndrome than a normal person. The background high blood viscosity might be clinically significant in COVID-19 vaccination. In this report, the underlying metabolic syndrome can significantly cause a higher increased blood viscosity after vaccination.

Comparing to healthy vaccine recipient, a recipient with metabolic syndrome has 1.07 times higher post vaccination blood viscosity level. There is a higher chance for hyperviscosity (above 5 cp [18]) after COVID-19 vaccination in a recipient with metabolic syndrome. Monitoring of the high blood viscosity problem among a vaccine recipient who is a patient with metabolic syndrome is necessary. This recommendation is similar to that for monitoring for a vaccine recipient who has an underlying cerebrovascular problem [19].

Nevertheless, an increasing blood viscosity in recipient with metabolic syndrome does not exceed hyperviscosity level. Hence, safety of using COVID-19 vaccine for a vaccine recipient with the underlying metabolic syndrome is confirmed. Nevertheless, a good control of blood glucose and lipid in a patient with metabolic syndrome before receiving COVID-19 vaccine is recommended. After COVID-19 vaccination, a good monitoring of blood glucose level is also recommended for vaccine recipient who has underlying diabetes [20, 21].

A limitation in this study is due to the nature of clinical modelling. The impact of other confounding factors affecting blood viscosity is omitted. In a real clinical situation, there might be effect of many confounding factors resulting in a very complex pathophysiology of problematic viscosity and thrombosis after COVID-19 vaccination.

Disclosure of conflict of interest

None.

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