

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/365463874>

Role of the immune system and possible mechanisms in COVID-19 vaccine-induced thyroiditis: Case report and literature review

Article in *Journal of Clinical and Translational Endocrinology Case Reports* · November 2022

DOI: 10.1016/j.jecr.2022.100138

CITATIONS

0

READS

27

6 authors, including:



Vahid Reisi-Vanani

Shahrekord University of Medical Sciences

9 PUBLICATIONS 17 CITATIONS

[SEE PROFILE](#)



Mahour Farzan

Shahrekord University of Medical Sciences

4 PUBLICATIONS 1 CITATION

[SEE PROFILE](#)



Mahan Farzan

Shahrekord University of Medical Sciences

4 PUBLICATIONS 1 CITATION

[SEE PROFILE](#)



Hosein Ataei Goujani

Shahrekord University of Medical Sciences

1 PUBLICATION 0 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



COVID-19 vaccine side effects and immunization [View project](#)



COVID-19 Among Patients With Down's Syndrome: A Systematic Review. [View project](#)



Contents lists available at ScienceDirect

Journal of Clinical and Translational Endocrinology: Case Reports

journal homepage: www.elsevier.com/locate/jctecasereports.com

Role of the immune system and possible mechanisms in COVID-19 vaccine-induced thyroiditis: Case report and literature review

Vahid Reisi-Vanani^a, Mahour Farzan^a, Mahan Farzan^a, Hosein Ataei-Goujani^a, Maryam Keihani^b, Golshan Taghipour-Boroujeni^{c,*}

^a Student Research Committee, Shahrekord University of Medical Sciences, Shahrekord, Iran

^b Department of Infectious Disease, Clinical Research Development Unit, Hajar Hospital, Shahrekord University of Medical Sciences, Shahrekord, Iran

^c Department of Internal Medicine, Clinical Research Development Unit, Hajar Hospital, Shahrekord University of Medical Sciences, Shahrekord, Iran

ARTICLE INFO

Keywords:

Subacute thyroiditis

SARS-CoV-2

COVID-19

Vaccine

Case report

Autoimmune/inflammatory syndrome induced by adjuvants/ASIA syndrome

ABSTRACT

Introduction: Subacute thyroiditis (SAT) is an inflammatory disease that has different trigger factors. Recent studies show the possible role of COVID-19 vaccine-induced thyroiditis in its initiation. Herein we report the first case of post-Sputnik V vaccination SAT.

Case presentation: A 42-year-old man without any specific disease was admitted due to tremors, palpation and sweating, and neck tenderness on the thyroid gland. Laboratory markers and radiologic assessments highlighted thyroiditis for him, and his symptoms were relieved by administering NSAIDs and corticosteroids.

Discussion: There are several hypotheses for the etiology of post-COVID-19 immunization SAT; among them, immunologic reactions like the interactivity of human proteome with viral components and autoimmune/inflammatory syndrome induced by adjuvants (ASIA) are more probable than other discussed possibilities. We suggest further studies to discover the exact SAT pathophysiology to prevent the underlying causes among future vaccine candidates.

1. Introduction

Subacute thyroiditis (SAT) is a rare inflammatory disorder that causes symptoms like thyrotoxicosis and throat tenderness. It usually occurs 1–2 weeks following viral infection. Difficulties in SAT diagnosis are due to its nonspecific clinical symptoms and self-limiting feature [1]. Patients with SAT can develop symptoms of hyperthyroidism, hypothyroidism, and complete recovery may even last several months. Untreated SATs can precede permanent complications. Since SAT is strongly associated with viral infections, an increase in SAT incidence seems possible during this COVID-19 pandemic [2]. Viruses are the leading cause of this condition, and adenovirus, enterovirus, coxsackievirus, mumps, measles, and recently coronaviruses had been reported to cause thyroiditis as thyroid cells could express angiotensin-converting enzyme-2 (ACE-2) receptors that might facilitate direct invasion of coronavirus to it [3]. To our knowledge, there are few reported cases of SAT following Sputnik V vaccination, and a review of literature on post-COVID-19 immunization SAT.

2. Case presentation

A 42-year-old man presented to the clinic with neck pain and swelling, difficulty in swallowing, occasional hot flashes, palpitation, tremors, fatigue, and malaise. He got the first dose of COVID-19 Sputnik V seven days before the initiation of his symptoms; He also did not have any past medical history and was infected with severe acute respiratory syndrome coronavirus 2 six months ago that was treated in outpatient settings. After the first dose administration, he felt symptoms like fatigue, fever and chills, sore throat, and myalgia persisting for about two days. Due to the COVID-19 pandemic, COVID-19 RT-PCR was done with a negative result for this virus and had tried to treat his symptoms with antihistamines and antibiotics without any consultation with a physician. Since his symptoms did not get better, he presented to a clinic 20 days after the initiation of symptoms. He also refused to inject the second dose of the vaccine. Since he had been participating in a study investigating post-vaccination antibody response (Ethic code: IR.SKUMS.REC.1400.090), his serum had been collected and stored before injection of the first vaccine dose. Sample analysis after the diagnosis of

* Corresponding author.

E-mail address: golshan.taghipour@gmail.com (G. Taghipour-Boroujeni).

<https://doi.org/10.1016/j.jecr.2022.100138>

Received 11 May 2022; Received in revised form 15 October 2022; Accepted 12 November 2022

Available online 17 November 2022

2214-6245/© 2022 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Table 1

Laboratory data of patient. First, second and third blood sample were gathered before vaccine injection, 23 days, and six month after the only vaccine dose.

Test	1st sample	2nd sample	3rd sample	Reference
T3	1.43	3.99	1.51	1.3–3.4 nmol/L
T4	83	271.6	88	66–180 nmol/L
TSH	5.18	0.1	3.50	0.25–5 mIU/mL
Anti-TPO	11.5		14.4	Positive: >40 IU/mL
Anti-TG	13.2		13.5	Normal: < 115 IU/mL
Anti-Spike antibody	26.3		100 \geq	Positive: \geq 8 RU/mL
WBC		12300		Negative: <8 4000–12000
Neutrophil		8856		
Lymphocyte		2091		
Mix%		1353		
ESR 1h		71		Normal: <15
CRP		++		

T3 Triiodothyronine, T4 thyroxine, TSH thyroid-stimulating hormone, Anti-TPO Anti-thyroid Peroxidase Antibody, Anti-TG Antithyroglobulin antibody, WBC white blood cells, ESR erythrocyte sedimentation rate, CRP C-reactive protein.

SAT revealed subclinical hypothyroidism for him before the administration of the vaccine. Because of his clinical signs and symptoms like neck tenderness on the thyroid gland, sweating, tremor, and palpation, laboratory (Table 1) and radiological assessments were conducted for him, including thyroid function tests and thyroid ultrasound. Thyroid ultrasound showed mild enlargement of the thyroid gland with hypo-echoic and heterogenic parenchyma in favor of acute thyroiditis. The radiologist also reported a hyper echo, well-defined solid nodule about 5.5 mm² in the upper part of the left lobe. Naproxen 750 mg/day and prednisolone 12 mg/day was prescribed for him for one week and was tapered in 4 weeks. As his thyroid function tests were in their normal range, levothyroxine had not been prescribed, and he did not use beta-blockers for his symptoms in the course of his disease.

3. Discussion

Subacute thyroiditis is a transient inflammation of the thyroid gland that occurs about 12/10000 per year in the United States. Its absolute etiology is still unknown, but epidemiological studies suggest an association between viral infections and its occurrence. Thyrotoxicosis symptoms besides neck tenderness and thyroid gland enlargement direct physicians to this diagnosis. Although a transient increase in anti-TPO antibody titer might occur during its course, other anti-thyroid antibodies are usually absent in this disease, and physicians screen TSH, fT4 (and sometimes fT3) in suspected patients [4]. Besides its self-limiting characteristic, some life-threatening adverse events especially due to thyrotoxicosis, including cardiac arrhythmias could occur, making its diagnosis, treatment, and follow-up important [5].

SAT occurrence after the COVID-19 infection made researchers mention the coronavirus in the group of viruses that could trigger SAT [6]. There are many theories about its etiology including: the direct invasion of the virus to the thyroid cells through ACE-2 and transmembrane protease serine 2 (TMPRSS2) receptors, inflammatory mechanisms, and even autoimmunity with viral components mimicking human proteome [7]. Besides COVID-19 infection, its vaccine can also be associated with SAT with several possible mechanisms. Autoimmune and immune-mediated reactions are one of the underlying theories. Reports of autoimmune hepatitis, type 1 diabetes mellitus, and Graves' disease after COVID-19 vaccination raised the possibility of immune-mediated mechanisms [8–12]. One probable reason is the cross-reactivity of the human proteome with virus components like spike protein, nucleoprotein, and membrane protein [13] which are the main target of vaccines. Sputnik V and other similar vaccines can trigger the immune system to produce IgG₁ monoclonal antibodies against the spike of the virus that has cross-reactivity with TPO, thyroglobulin, and other

cellular components of the thyroid gland [14], structural similarities between antibodies induced by vaccine and human tissue antigens are demonstrated in a study [15], that might be the triggering point for post-vaccination autoimmunity. The presented case was infected with COVID-19, and his anti-spike antibody titer was positive before vaccination. Although he had injected just the first dose of vaccine, his high antibody titer could explain somehow the relationship between vaccine-induced antibody and following SAT.

Another immune-mediated reaction that can induce autoimmune disease, especially endocrinopathies, is autoimmune/inflammatory syndrome induced by adjuvants (ASIA). Many autoimmune disorders have been reported with vaccines using adjuvants in their ingredients to increase the efficacy of immunization; These substances can disturb immunoregulatory checkpoints, lead to polyclonal stimulation of B lymphocytes which affects T lymphocytes besides disturbance of regulatory cells that can trigger the production of viral-induced antibodies with the ability of binding to endogenous proteins for their molecular similarities. Hashimoto's thyroiditis, Graves' disease, primary ovarian failure, and type 1 diabetes mellitus have been reported after several vaccine adjuvants [16]. Many researchers suggest the role of ASIA in post-COVID-19 immunization thyroiditis [13,14,17] besides other endocrinopathies after vaccination like hypophysitis [18]. Although ASIA seems to justify these disturbances, many controversies about the duration of post-vaccination disease, especially in acute thyroiditis, suggest modifying the diagnosis criteria of ASIA [19] and investigating more accurate studies on it.

Recent studies show an association between SAT and the presence of HLA-B*35, HLA-B*18:01, DRB1*01, and C*04:01 which demonstrates the genetic susceptibility of patients that can also affect their duration and type of treatment [20,21]. Unlike chronic thyroiditis which involves both cellular and humoral immunity, cytotoxic T cells play a significant role in SAT pathogenesis by recognizing the viral and thyroid cell antigens and inducing transient inflammation [22].

There are many reports of SAT after COVID-19 immunization that usually occurred 4–7 days after the injection, as is demonstrated in Table 2 [13] which is consistent with our case and would help its diagnosis if physicians know the characteristic of post-vaccination thyroiditis.

Discussing mentioned hypothesis for the etiology of post-COVID-19 immunization SAT, the possibility that the onset of SAT after the vaccine could be just a mere coincidence should be pointed out. If ASIA has stronger evidence, administration of a different vaccine with different adjuvants would diminish the possibility of thyroiditis after booster doses. Finally, we suggest more studies on the underlying mechanisms.

Table 2
Clinical manifestation and medication of sub-acute thyroiditis followed by COVID-19 vaccination.

S*	Age/ Sex	Vaccine	PMH	vaccination to SAT	SAT sign and Symptoms	Medication	S	Age/ Sex	Vaccine	PMH	vaccination to SAT	SAT sign and Symptoms	Medication
[24]	67/ M*	CoronaVac® (Sinovac Life Sciences, Beijing)	HTN*	17 days after 2nd dose	Hypertension, Weight loss, Fever, Mild pain in anterior neck and left ear, minimal tenderness in the thyroid palpation	Lercanidipine Paracetamol ibuprofen	[23]	55/F	AstraZeneca (ChAdOx1 nCoV-19 vaccine)	well- controlled asthma	3 weeks after 1st dose	Neck pain and swelling for 4 weeks, headache, sore throat, myalgia, and palpitations swelling in the neck, pain, fatigue, loss of appetite and sweating, stage 2 goitre, tenderness over the right thyroid lobe	Propranolol Ibuprofen Paracetamol Levothyroxine
[26]	34/ F*	COVAXIN(The Bharat BiotechCOVID- 19Vaccine)	No PMH*	5th-7th day post vaccination	Intermittentmild fever, palpitation and radiating anterior neck pain, thyroid gland enlargement and tender	prednisolone	[25]	38/F	CoronaVac® (Sinovac Life Sciences, Beijing)	No PMH	2 weeks after the second dose	nausea, mild anterior neck pain and fever up to 38,2 °C tender in thyroid gland on palpation headache, fever, neck pain and tenderness, shortness of breath, intermittent palpitations, insomnia and anxiety, tachycardia	Naproxen sodium Propranolol Levothyroxine
[28]	42/F	Pfizer/ BioNTech	No PMH	5 days after first dose	sore throat and palpitationsheart rate in the 130swith sinus tachycardia on EKG	Ibuprofen Prednisone Propranolol	[27]	51/F 39/F	Pfizer/ BioNTech AstraZeneca (ChAdOx1 nCoV-19 vaccine)	No PMH No PMH	4 days after receiving the first dose 3 weeks	headache, fever, neck pain and tenderness, shortness of breath, intermittent palpitations, insomnia and anxiety, tachycardia	Methylprednisolone No special treatment
[29]	26/F 49/F	Vaxzervria (AstraZeneca; Sweden) Spikevax (Moderna Biotech, Spain)	No PMH Benign thyroid nodules	2 weeks after the first dose 2 weeks after the first dose	Cervical pain that radiated to both ears, fever and chills, tenderness in the thyroid Sore throat, headaches and difficulty in concentrating, right cervical pain radiating to the ear	Ibuprofen Prednisolone Ibuprofen Diclofenac Prednisolone	[30]	75/M	AstraZeneca (ChAdOx1, Vaxzervria).	No significant PMH	14 days	progressive anterior neck pain and swelling, fever (38.3), right thyroid gland enlargement with diffuse tenderness	Ibuprofen
[13]	35/F 34/F 37/F	CoronaVac® (Sinovac Life Sciences, Beijing) (CoronaVac®, Sinovac Life Sciences, Beijing) (CoronaVac®, Sinovac Life Sciences, Beijing)	No PMH Covid-19 No PMH	4 days after the second dose 4 days after first dose 7 days after the second dose	Severe sore throat, palpitation, fever, fatigue, sensitive, painful, and enlarged thyroid gland anterior neck pain, fatigue, weight loss, palpitations, myalgia mild anterior neck pain, mild tenderness over the right lobe of the thyroid gland, palpated, sensitive and enlarged right lobe of thyroid (at 4th week)	Paracetamol Methylprednisolone Propranolol Methylprednisolone Propranolol Paracetamol	[31]	57/F	Pfizer/ BioNTech	No PMH	34 days after first dose 13 days after second dose	Poor sleep, worsening night sweats, hyper defecation, weight loss, neck pain, swelling, and tenderness	Propranolol Ibuprofen Prednisone
							[14]	middle- aged/F	Pfizer/ BioNTech	No PMH	2 weeks after the second dose	A tender, swollen area with increased warmth and firm consistency was	NSAID*
							[32]	46/F	Moderna mRNA-1273 SARS-CoV-2	migraine	32 days after the first dose and immediately after the second dose		Dexamethasone Propranolol methylprednisolone

(continued on next page)

Table 2 (continued)

S*	Age/ Sex	Vaccine	PMH	vaccination to SAT	SAT sign and Symptoms	Medication	S	Age/ Sex	Vaccine	PMH	vaccination to SAT	SAT sign and Symptoms	Medication
[33]	42/F	Moderna mRNA COVID-19 vaccine	Colon cancer	6 days after second dose	bilateral ear pain right- sided and then left-sided earache radiating down to the lateral and anterior neck and bilateral lower jaw, ear pain was exacerbated by turning her head, swallowing, and coughing, anterior neck swelling	NSAID	35	46/F 73/F 34/F 33/M	AstraZeneca AstraZeneca Janssen (Johnson & Johnson) Janssen (Johnson & Johnson)	No PMH No PMH No PMH No PMH	1 day after first dose 14 days after second dose 14 days after the vaccine 10 days after the vaccine	noted on the anterior neck Chest pain Dyspnea Weight loss Dyspnea Weight loss Palpitation Both leg weakness	Not mentioned Not mentioned Not mentioned Not mentioned
[34]	40/F 28/F	Pfizer/ BioNTech Pfizer/ BioNTech	Covid-19 HTN Infertility No PMH	2 days after the vaccine 3 days after the vaccine	Nausea, vomiting, fatigue, insomnia, palpitations, fine distal tremors, increased stretch reflexes, and arhythmic heart sounds Anxiety, insomnia, palpitations, and a distal tremor	Propranolol Diltiazem Ivabradine Thiamazole Propranolol Thiamazole	Our case	42/M	Sputnik V (Gam-COVID- Vac)	Covid-19 6 months ago	7 days after first dose	Neck pain, swelling, difficulty in swallowing, occasional hot flashes, palpation, tremor, fatigue, and malaise	Naproxen Prednisolone
[35]	39/F 73/F 39/ M	AstraZeneca AstraZeneca Janssen (Johnson & Johnson)	No PMH No PMH No PMH	4 days after second dose 11 days after first dose 14 days after the vaccine	Neck pain Fever Neck pain Fever Neck pain	Not mentioned Not mentioned Not mentioned							

S study, F female, M male, PMH past medical history, HTN hypertension, NSAID nonsteroidal anti-inflammatory drug, SAT subacute thyroiditis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- [1] Bostan H, Sencar ME, Calapkulu M, Hepsen S, Duger H, Unsal IO, et al. Two important issues in subacute thyroiditis management: delayed diagnosis and inappropriate use of antibiotics. *European Thyroid Journal* 2021;1–7.
- [2] Gorges J, Ulrich J, Keck C, Müller-Wieland D, Diederich S, Janssen OE. Long-term outcome of subacute thyroiditis. *Exp Clin Endocrinol Diabetes* 2020;128(11):703–8.
- [3] Coperchini F, Ricci G, Croce L, Denegri M, Ruggiero R, Villani L, et al. Modulation of ACE-2 mRNA by inflammatory cytokines in human thyroid cells: a pilot study. *Endocrine* 2021;74(3):638–45.
- [4] Reismann P. Subacute (de Quervain's) thyroiditis. *Pract. Clin. Endocrinol.* 2021:171–7.
- [5] Brancatella A, Ricci D, Cappellani D, Viola N, Sgrò D, Santini F, et al. Is subacute thyroiditis an underestimated manifestation of SARS-CoV-2 infection? Insights from a case series. *J Clin Endocrinol Metab* 2020;105(10):e3742–6.
- [6] Ruggeri RM, Campenni A, Siracusa M, Frazzetto G, Gullo D. Subacute thyroiditis in a patient infected with SARS-CoV-2: an endocrine complication linked to the COVID-19 pandemic. *Hormones (Basel)* 2021;20(1):219–21.
- [7] Siolos A, Gartzonika K, Tigas S. Thyroiditis following vaccination against COVID-19: report of two cases and review of the literature. *Metabolism open* 2021:100136.
- [8] Bril F, Al Diffalha S, Dean M, Fettig DM. Autoimmune hepatitis developing after coronavirus disease 2019 (COVID-19) vaccine: causality or casualty? *J Hepatol* 2021;75(1):222–4.
- [9] Ghielmetti M, Schaufelberger HD, Mieli-Vergani G, Cerny A, Dayer E, Vergani D, et al. Acute autoimmune-like hepatitis with atypical anti-mitochondrial antibody after mRNA COVID-19 vaccination: a novel clinical entity? *J Autoimmun* 2021;123:102706.
- [10] Vuille-Lessard É, Montani M, Bosch J, Semmo N. Autoimmune hepatitis triggered by SARS-CoV-2 vaccination. *J Autoimmun* 2021;123:102710.
- [11] Two cases of graves' disease following SARS-CoV-2 vaccination: an autoimmune/inflammatory syndrome induced by adjuvants. *Thyroid* 2021;31(9):1436–9.
- [12] Patrizio A, Ferrari SM, Antonelli A, Fallahi P. A case of Graves' disease and type 1 diabetes mellitus following SARS-CoV-2 vaccination. *J Autoimmun* 2021;125:102738.
- [13] İremli BG, Şendur SN, Ünlütürk U. Three cases of subacute thyroiditis following SARS-CoV-2 vaccine: post-vaccination ASIA syndrome. *J Clin Endocrinol Metab* 2021.
- [14] Jeeyavudeen MS, Patrick AW, Gibb FW, Dover AR. COVID-19 vaccine-associated subacute thyroiditis: an unusual suspect for de Quervain's thyroiditis. *BMJ Case Reports* 2021;14(11):e246425.
- [15] Vojdani A, Vojdani E, Kharrazian D. Reaction of human monoclonal antibodies to SARS-CoV-2 proteins with tissue antigens: implications for autoimmune diseases. *Front Immunol* 2021;11:3679.
- [16] Watad A, David P, Brown S, Shoenfeld Y. Autoimmune/inflammatory syndrome induced by adjuvants and thyroid autoimmunity. *Front Endocrinol* 2017;7:150.
- [17] Das L, Bhadada S, Sood A. Post-COVID-vaccine autoimmune/inflammatory syndrome in response to adjuvants (ASIA syndrome) manifesting as subacute thyroiditis. *J Endocrinol Invest* 2021:1–3.
- [18] Murvelashvili N, Tessnow A. A case of hypophysitis following immunization with the mRNA-1273 SARS-CoV-2 vaccine. *J Invest Med High Impact Case Rep.* 2021;9:23247096211043386.
- [19] Shoenfeld Y, Agmon-Levin N. 'ASIA'—autoimmune/inflammatory syndrome induced by adjuvants. *J Autoimmun* 2011;36(1):4–8.
- [20] Stasiak M, Tymoniuk B, Michalak R, Stasiak B, Kowalski ML, Lewiński A. Subacute thyroiditis is associated with HLA-B* 18: 01,-DRB1* 01 and-C* 04: 01—the significance of the new molecular background. *J Clin Med* 2020;9(2):534.
- [21] Stasiak M, Tymoniuk B, Stasiak B, Lewiński A. The risk of recurrence of subacute thyroiditis is HLA-dependent. *Int J Mol Sci* 2019;20(5):1089.
- [22] Kojima M, Nakamura S, Oyama T, Sugihara S, Sakata N, Masawa N. Cellular composition of subacute thyroiditis. an immunohistochemical study of six cases. *Pathol Res Pract* 2002;198(12):833–7.
- [23] Oyibo SO. Subacute thyroiditis after receiving the adenovirus-vectored vaccine for coronavirus disease (COVID-19). *Cureus* 2021;13(6).
- [24] Şahin Tekin M, Şaylısoy S, Yorulmaz G. Subacute thyroiditis following COVID-19 vaccination in a 67-year-old male patient: a case report. *Hum Vaccines Immunother* 2021:1–3.
- [25] Saygılı ES, Karakılıç E. Subacute thyroiditis after inactive SARS-CoV-2 vaccine. *BMJ Case Reports* 2021;14(10):e244711.
- [26] Soltanpoor P, Norouzi G. Subacute thyroiditis following COVID-19 vaccination. *Clin Case Rep* 2021;9(10):e04812.
- [27] Siolos A, Gartzonika K, Tigas S. Thyroiditis following vaccination against COVID-19: report of two cases and review of the literature. *Metabolism open* 2021;12:100136.
- [28] Bahl S, Babu PM, Capatana F, Khan I, Adlan M, Premawardhana LD. Sub-acute thyroiditis presenting as pyrexia of unknown origin. *J Endocr. Soc.* 2021;5 (Supplement_1):A956–.
- [29] Bornemann C, Woyk K, Bouter C. Case report: two cases of subacute thyroiditis following SARS-CoV-2 vaccination. *Front Med* 2021;8.
- [30] Ratnayake GM, Dworakowska D, Grossman AB. Can COVID-19 immunisation cause subacute thyroiditis? *Clin Endocrinol* 2021.
- [31] Schimmel J, Alba EL, Chen A, Russell M, Srinath R. Letter to the editor: thyroiditis and thyrotoxicosis after the SARS-CoV-2 mRNA vaccine. *Thyroid* 2021;31(9):1440.
- [32] Patel M, Shahid M, Khawaja A, Ejike C, Vemuri K. Subacute thyroiditis secondary to moderna COVID-19 vaccine: a case report of a rare manifestation. *Adv Clin Med Res Healthc Deliv* 2021;1(2):9.
- [33] Plaza-Enriquez L, Khatiwada P, Sanchez-Valenzuela M, Sikha A. A case report of subacute thyroiditis following mRNA COVID-19 vaccine. *Case Rep Endocrinol.* 2021.
- [34] Vera-Lastra O, Ordinola Navarro A, Cruz Domiguez MP, Medina G, Sánchez Valadez TI, Jara LJ. Two cases of Graves' disease following SARS-CoV-2 vaccination: an autoimmune/inflammatory syndrome induced by adjuvants. *Thyroid* 2021.
- [35] Lee K, Kim YJ, Jin HY. Thyrotoxicosis after COVID-19 vaccination: seven case reports and a literature review. *Endocrine* 2021;74(3):470–2.