University of Thi-Qar Journal of Science (UTJsci)
E-ISSN:2709-0256, P-ISSN: 1991-8690, Vol. (10), No.1(Special Issue: ISCAMET), April 2023

Evaluation of thyroid function in people vaccinated against COVID-19 via Sinofarm type

Tabarak Odai Abd Alrazaq
Pathological analysis
College of Science
University of Basrah
Basra/ Iraq

Hanaa S. Kadhum
Pathological analysis
College of Science
University of Basrah
Basra/ Iraq

Ola Abdul Shaheed Naser
Pathological analysis
College of Science
University of Basrah
Basra/Iraq
ola.naser@uobasrah.edu.iq

Sundus Waleed Khalid
Pathological analysis
College of Science
University of Basrah
Basra/ Iraq
sundus.khalid@uobasrah.edu.iq

Hussein Bassem Abd
Pathological analysis
College of Science
University of Basrah
Basra/ Iraq

Mahdi M. Thuwaini
College of healthy and medical techniques
medical Laboratories department
University of Southern Techniques
Basra/ Iraq
mahdi.murshd@stu.edu.iq

Nour El- Huda hkalid Eid
Pathological analysis
College of Science
University of Basrah
Basra/ Iraq

Aya Abdel-Zahra Abboud
Pathological analysis
College of Science
University of Basrah
Basra/ Iraq

***Abstract*— Background; Since the emergence of the coronavirus disease pandemic, several effective vaccines have been introduced. These vaccines work through several different immunogenic pathways to produce effective immunity. There have been a number of reports of patients developing sub-acute thyroiditis and thyroid dysfunction after receiving the coronavirus (COVID-19) vaccine. This study aims to demonstrate the physiological effect of the covid -19 vaccine on human thyroid hormone. Methodology; For this purpose, 25 samples of male and female blood from people vaccinated with the corona virus used, 25 samples of blood from unvaccinated people were considered as a control group. The effect of this vaccine on the functions of the thyroid gland and on the concentrations of hormones was shown. A significant increase in the concentration of hormone T4 was observed in the group of vaccinated people compared to the control group. Conclusion, the current study Showed that the level of hormones increased significantly in the vaccinated compared to the control group, as well as concluded these results was indicate that thyroid function is negatively affected by the vaccine.**

***Keywords*— COVID-19, Vaccine, Sinofarm, Thyroid, T3, T4, TSH.**

I. INTRODUCTION

Coronavirus disease 2019 (COVID-19): caused by SARS-CoV-2 infection had broken out in China in December 2019 and then rapidly spread all over the world creating a global pandemic (1). Patients with COVID-19 suffer from high mortality due not only to respiratory failure but also to other complications such as cardiovascular collapse and disseminated intravascular coagulation (2, 3). In addition, there have been co-morbidities including autoimmune diseases associated with COVID-19 such as Guillain–Barre's syndrome (4), autoimmune hemolytic anemia (5), and autoimmune thrombocytopenic purpura (6). Recently, evidence has been accumulated for changes in thyroid function and thyroid diseases associated with COVID-19 (7–8). Review articles on this topic have also been rapidly published (9–10). Thyroid gland is an endocrine gland found in vertebrates. However, Although there are no good data examining the difference in incidence of COVID-19 between men and women, more men than women have died of COVID-19 in 41 of 47 countries and the overall case-fatality ratio is ~2.4 times higher among men than women (36). Epidemiologic studies suggest a significant male sex susceptibility for more severe COVID-19 symptoms (18, 19). There are a couple proposed theories as to why there are sex differences in COVID-19 outcomes. First, the gene for ACE2 located on short arm of the X chromosome. In females, one of the two X chromosomes is silenced causing condensation of the X chromosome into a Barr body; but some genes, particularly those on the short arm, escape this inactivation (37, 38). This increased expression of ACE2 in females may be protective against more severe COVID-19 symptoms as viral saturation is less likely to occur and ACE2 regulates the renin-angiotensin system, which protects against vascular compromise and severe organ damage (38). Anyway, coronaviruses (CoVs) are subdivided into four genera2 such as Alphacoronavirus, Betacoronavirus (βCoV), Gammacoronavirus, and Deltacoronavirus (25). Alteration of the thyroid functionality has been documented in patients with SARS during the 2002 outbreak. Transient subclinical thyrotoxicosis, central hypothyroidism, and primary hypothyroidism were previously reported in patients with SARS (26). Other worker was reported that thyroidstimulating hormone (TSH) and adrenocorticotropin (ACTH) staining of thyrotrophs and corticotrophs, respectively, was significantly attenuated in the pituitary gland of patients with SARS upon autopsy (27). Apoptosis of the thyroid follicular cells was seen in SARS (36), but the information on the thyroid function of the patients was not provided (28). Therefore, primary hypothyroidism in this patient may or may not have been a consequence of the direct viral attack on the thyroid follicular cells (29). However, Entry into host cells is facilitated by the viral spike protein and host cell receptor angiotensin – converting

enzyme 2 (ACE2) [30]. Once the spike protein binds to ACE2, Trans membrane protease serine 2 (TMPRSS2) on the host cell surface primes the spike protein and other cellular proteases to cleave the spike protein into two subunits. This then allows for viral entry and release of viral RNA so that viral genome replication and transcription can begin (30). It is estimated that between 15% and 30% of hospitalized COVID-19 patients have thyroid dysfunction, however, most of these changes appear to be limited and that thyroid function in most patients will return to normal once the infection clears (31). Nevertheless, there are two types of thyroid dysfunction that appear to be clearly associated with COVID-19 infection: Hypothyroidism due to non-thyroidal illness syndrome NTIS, which is changes in the levels of thyroid hormone in the blood observed in severely ill patients with the absence of pituitary and thyroid dysfunction. It is welldocumented that "Covid-19" can cause the release of large amounts of cytokines associated with inflammation, and therefore it is logical that nonthyroid disease syndrome can be caused by "Covid-19" infection (32). _Thyrotoxicosis, which is an overactive thyroid gland (hyperthyroidism) due to sub-acute thyroiditis that results from a viral infection, in this case the virus is corona. [33] Thyrotoxicosis rates are significantly higher among those with severe cases of "Covid-19" compared to those with severe diseases, but not "Covid-19", which indicates an atypical form of thyroiditis associated with infection with the Corona virus (33). However, the coronavirus, whose scientific name is SARS-CoV-2, enters human cells through the angiotensin-converting enzyme 2 (ACE2) receptor, which is found in thyroid follicular cells, making thyroid tissue a potential target as direct infection with the Corona virus (34, 35).

This study was aimed to Vaccination with the Sinopharm vaccine is highly effective against the tyrannical Corona virus that has spread all over the world. He brought the researchers' attention to focus on this vaccine in a large way by relying on statistics to know the effect of the vaccine on the functions of organs in the human body. In addition, we will shed light in this research on the Sinopharm vaccine and the fact that it affects the level of thyroid hormones T3, T4, and TSH in people vaccinated with this vaccine.

II. MATERIALS AND METHODS

A. Study design

This study included 25 male and female subjects who were vaccinated with Sino pharm type vaccine. In addition, the study included (25) healthy unvaccinated people as a control. The ages of the study population ranged (20-35 years). Markers measurement included _Triiodothyronine (T3) _Thyroxin (T4) _thyroid-stimulating hormone (TSH).

B. Sample collection

The blood sampling was collected from individuals of both groups (vaccinated _non vaccinated subjects), 5ml of venous blood samples were collected to obtain serum by placing blood in a vacuum sterile gel, clot activator tube to clot at 37c°. For centrifugation. The tube were centrifugalized at (1500rpm). For 5 minutes. Serum was collected and kept in freeze. It was used for hormonal assay, which include measuring the level of thyroid hormones.

C. Statistical analysis

Data are stated as means (-+SD) and median (mix_max) difference between two groups by Mann-Whitney test and Chi-Square Test. All Statistical analysis were performed using SPss for windows (version 23, usA). A value of $P < 0.05$ was considered statistically significant.

III. RESULTS AND DISCUSSION

The result of this study as shown in table (1) was displayed that there is not statistically significant variations regarding age between control and vaccinated individuals (P= 0.873). While in table (2) there are significant differences between the sexes (p= 1.000).The study also showed in **table** (3), that there was a significant increase in T4 hormone concentrations (p= 0.0001) and no significant differences with respect to hormones T3 and TSH in both group. Table (4) also showed there was no statistical correlation between the two groups for hormones T3, T4, TSH. Thyroxine (T4) is the main hormone produced by the gland and is responsible for the basic metabolic activity. This hormone is found in the blood and is bound to a protein called thyroxinebinding globulin and is only that can enter cells and cause metabolic activity TS. This study shows the effect of vaccine on thyroid hormone, as indicated by T4, TSH. It shows that there were an elevated values of T4 hormone , vaccinated people at (p=0.0001) in comparison with the control subjects as shown in (Table 2), these findings are agreement with the results of other studies[40].the vaccine may to cause follicular destruction and rapid release of preformed thyroid hormone[41] . Lastra et al. noted that Graves' disease might occur after covid -19 vaccinations [42] and noted that adjuvants might induce disorder. Recently, there have been some reports on thyroid problems following vaccinations. Nevertheless, there might also be other possible pathomechanisms. Pathophysiologically, administration of the COVID-19 vaccine results in increased blood viscosity and might cause hyperviscosity [43]. If hyperviscosity occurs, it can result in an aberrantly increased thyroid hormone level [44] Genetically Thyroid function abnormalities are a widely reported endocrine manifestation associated with COVID-19 infection. May be due to disorder in expression of som genes, Evidence for the presence of ACE2 receptors and TMPRSS2 in thyroid cells has been established [45] The expression of ACE2 in the hypothalamus was confirmed by Chigr et al., who identified the presence of ACE2 in the paraventricular nucleus, based on autopsy findings,have been reported. The cerebrospinal fluid of a patient with COVID-19, 16 thereby confirming that SARS-CoV-2 does indeed infiltrate into the brain, and hence can involve any part of the brain, includingthe hypothalamus and pituitary [46] In a study by Lania et al., a significant number of patients (20.2%) hospitalized for COVID-19 were found to have thyrotoxicosis in absence of neck pain, likely identifying patients with COVID19related painless (silent/atypical). Study by Lania et.al.,[47] (2020), the high prevalence of atrial fibrillation and the close relationship between suppressed TSH and high mortality rate and longer hospitalization suggest that thyrotoxicosis may be clinically relevant in COVID-19 patients. In other hand, an alternative hypothesis is the possible direct action of SARS-CoV-2 on thyroid gland [48], based on the evidence that several tissues and organs may be directly damaged by the virus during COVID-19 [49] Indeed, there is evidence that thyroid tissue highly expresses the angiotensin-converting enzyme 2[50], which is the protein used by SARSCoV-2 for

invading human cells. In conclusion, the current study showed that the level of hormones increased significantly in the vaccinated compared to the control group, and this increase is statistically significant.

IV CONCLUSION

We conclude from all these results that they indicate that the vaccine negatively affects thyroid function.

TABLE (1): Comparison of thyroid hormone test between non-vaccinated people (control) and vaccinated people according to sex

Sex	Category		P-Value
	control (n=25)	Vaccinated (n=25)	
	Mean+ SD	Mean+ SD	
Male	41.7%	41.7%	1.000*
Female	58.3%	58.3%	
Total	25	25	

* Chi-Square Test

TABLE (2): Shows Comparison of thyroid hormone test parameters between non-vaccinated people (control) and vaccinated people

Parametersor Variables	Category		P-Value
	control (n=25)	Vaccinated (n=25)	
	Mean+ SD	Mean+ SD	
Age	21.71+1.706	22.17+3.485	0.873
TSH (Miu/l)	0.9875+0.31112	1.0208+0.58445	0.741
T4(nmol/l)	85.9583+7.63561	222.4021+60.50899	0.0001*
T3 (nmol/l))	1.4250+0.17258	1.9708+1.67867	0.077

*Mann-Whitney test

TABLE (3): Spearmans correlation between non-vaccinated people (control) and vaccinated people

Category			TSH	T4	TSH
Control	**Age**	**R**	0.023	0.346	0.393
		Sig.	0.917	0.098	0.057
		N	25	25	25
	TSH	**R**		0.005	0.077
		Sig.		0.982	0.721
		N		25	25
	T4	**R**			0.228
		Sig.			0.284
		N			24
Vaccinated	**Age**	**R**	0.081	0.106	-0.003-
		Sig.	0.706	0.621	0.989
		N	25	25	25
	TSH	**R**		-0.238-	-0.029-
		Sig.		0.263	0.892
		N		25	25
	T4	**R**			-0.041-
		Sig.			0.850
		N			25

Declarations

Author contributions

The authors, drafted the approved the manuscript.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical approval

The authors had perform experimental and clinical work.

Consent to participate

Experimental and clinical work by authors

Consent to publication

The manuscript did not contain any personal data.

Availability of data and materials

Applicable

Funding

The authors received no fund from any source

ACKNOWLEDGEMENTS

The authors acknowledge the participant (Awatif Hamid Issa) who consented to participate in this study. We are indebted to her contribution. In addition, for her kind cooperation.

REFERENCES

1. Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, et al. Clinical Course and Outcomes of Critically Ill Patients With SARS-CoV-2 Pneumonia in Wuhan, China: A Single-Centered, Retrospective, Observational Study. Lancet Respir Med (2020) 8:475–81. 10.1016/S22132600 (20)30079-5_2.

2. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical Features of Patients Infected With 2019 Novel Coronavirus in Wuhan, China. Lancet (2020) 395(10223):497–506. Doi: 10.1016/S0140-6736(20)30183-5

3. Zhang Y, Xiao M, Zhang S, Xia P, Cao W, Jiang W, et al. Coagulopathy and Antiphospholipid Antibodies in Patients With COVID-19. N Engl J Med (2020) 382:e38.Doi: 10.1056/NEJMc2007575.

4. Toscano G, Palmerini F, Ravaglia S, Ruiz L, Invernizzi P, Cuzzoni MG, et al. Guillain-Barré Syndrome Associated With SARS-Cov-2. N Engl J Med (2020) 382:2574–6. Doi: 10.1056/NEJMc2009191.

5. Lazarian G, Quinquenel A, Bellal M, Siavellis J, Jacquy C, Re D, et al. Autoimmune Haemolytic Anaemia Associated With COVID-19 Infection. Br J Haematol (2020) 190:29–31. Doi: 10.1111/bjh.16794

6. Zulfiqar AA, Lorenzo-Villalba N, Hassler P, Andrès E. Immune Thrombocytopenic Purpura in a Patient with Covid-19. N Engl JMed (2020) 382(18):e43. Doi: 10.1056/NEJMc2010472.

7. 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 ClinEndocrinol Metab(2020) 105:dgaa537. Doi: 10 Asfuroglu Karkan E, Ates I. A Case of Subacute Thyroiditis

8. Associated With Covid-19 Infection. J Endocrinol Invest (2020)

9. 43(8):1173–4. Doi: 10.1007/s40618-020-01316- Ippolito S, Dentali F, Tanda ML. Sars-CoV-2: A Potential Trigger for Subacute Thyroiditis. Insights Case Rep J Endocrinol Invest 21 (2020) 43(8):1171–2. Doi: 10.1007/s40618-020-01312-7..1210/clinem/dgaa537.

10. Asfuroglu Karkan E, Ates I. A Case of Subacute Thyroiditis.

11. Associated With Covid-19 Infection. J Endocrinol Invest (2020) 43(8):1173–4. Doi: 10.1007/s40618-020-01316- .

12. Ippolito S, Dentali F, Tanda ML. Sars-CoV-2: A Potential Trigger for Subacute Thyroiditis? Insights Case Rep J Endocrinol Invest (2020) 43(8):1171–2. Doi: 10.1007/s40618-020-01312-7.

13. Brancatella A, Ricci D, Viola N, Sgrò D, Santini F, Latrofa F. Subacute Thyroiditis After Sars-COV-2 Infection. J Clin Endocrinol. Metab (2020) 105(7):dgaa276. Doi: 10.1210/clinem/dgaa276 Edit Guyton & Hall 2011, p. 907.

14. Boron WF, Boulpaep EL (2012). Medical Physiology (2nd Ed.). Philadelphia: Saunders. P. 1052. ISBN 978-1-4377-1753-2.

15. Harrison's 2011, pp. 2913, 2918.

16. Bowen, R. (2010-07-24). "Physiologic Effects of Thyroid Hormones". Colorado State University. Retrieved 2013-09-29.

17. "How Your Thyroid Works – "A delicate Feedback Mechanism"". Endocrineweb. 2012-01-30. Retrieved 2013-09-29.

18. .K. Siddle, J. C. Hutton, Peptide Hormone Secretion/Peptide Hormone Action: A Practical Approach, Oxford University Press, 1991, ISBN 0-19963073-9. 22

19. J. C. Hutton, Peptide Hormone Secretion: A Practical Approach, Hull University Press, 1991, ISBN 0-19-963068-2.

20. C. G. Wermuth, the Practice of Medicinal Chemistry, Academic Press, 2003, ISBN 0-12-744481-5. 23.

21. William J. Kraemer, Alan D. Rogol, the Endocrine System in Sports and Exercise, Blackwell Publishing, 2005, ISBN 1-4051-3017-2.

22. Cicekcibasi AE, Salbacak A, Seker M, Ziylan T, Tuncer I, Buyukmumcu M (April 2007). "Developmental variations and clinical importance of the fetal thyroid gland. A morphometric study". Saudi Medical Journal. 2007; 28 (4): 524–8.

23. Preedy, Victor (2009) ،Comprehensive Handbook of Iodine Nutritional, Biochemical, Pathological and Therapeutic Aspects, Dean DS, Gharib H (December 2008). "Epidemiology of thyroid nodules". Best Practice & Research. Clinical Endocrinology & Metabolism.

24. İnandıklıoğlu N, Akkoc T. Immune Responses to SARS-CoV, MersCoV and SARS-Cov-2. Adv Exp Med Biol (2020) 1288:5–12. Doi: 10.1007/5584_2020_549.

25. Leow MK, Kwek DS, Ng AW, Ong KC, Kaw GJ, Lee LS. Hypocortisolism in Survivors of Severe Acute Respiratory Syndrome (SARS). Clin Endocrinol (Oxf.) (2005) 63:197–202. Doi: 10.1111/j.1365-2265.2005.02325.x.

26. Wei L, Sun S, Zhang J, Zhu H, Xu Y, Ma Q, et al., Endocrine Cells of the Adenohypophysis in Severe Acute Respiratory Syndrome (SARS). Biochem Cell Biol (2010) 88(4):723–30. Doi: 10.1139/O10022. 28.

27. Wei L, Sun S, Xu CH, Zhang J, Xu Y, Zhu H, et al. Pathology of the Thyroid in Severe Acute Respiratory Syndrome. Hum Pathol (2007) 38:95–102. Doi: 10.1016/j.humpath.2006.06.011.

28. Ding Y, He L, Zhang Q, Huang Z, Che X, Hou J, et al. Organ Distribution of Severe Acute Respiratory Syndrome (SARS) 23 Associated Coronavirus (SARS-CoV) in SARS Patients: Implications for Pathogenesis and Virus Transmission Pathways. J Pathol (2004) 203(2):622–30. Doi: 10.1002/path.1560.

29. Fliers E, Bianco AC, Langouche L, Boelen A. Thyroid Function in Critically Ill Patients. Lancet Diabetes Endocrinol (2015) 3 (10):816– 25. Doi: 10.1016/S2213-8587(15)00225-9.

30. Wei L, Sun S, Xu CH, et al. Pathology of the thyroid in severe acute respiratory syndrome. Hum Pathol.2007; 38(1): 95-102.

31. Ding Y , He L, Zhang Q, et al. Organ distribution of severe acute respiratory syndrome (SARS) associated coronavirus (SARS-CoV) in SARS patients: implications for pathogenesis virus transmission pathways. J Pathol.2004; 203(2): 622-630.

32. Wei L, Sun S, Zhang J, et al. Endocrine cells of the adenohypophysis in severe acute respiratory syndrome (SARS). Biochem Cell Biol.2010; 88(4):723-730.

33. Li H , Liu SM, Yu XH, Tang SL, Tang CK. Coronavirus disease 2019 (COVID-19): current status and future perspectives. Int J Antimicrob Agents.2020; 55(5):105951.

34. Brancatella A, Ricci D, Cappellani D, et al. Is subacute thyroiditis an underestimated manifestation of SARS-CoV-2 infection? Insights from a case series. [Published online ahead of print August 11, 2020.] J Clin Endocrinol Metab. Doi: 10.1210/clinem/dgaa537.

35. Haider N.J., Mahdi M. T., Hamed J. A., 2022; Determination of some biomarkers as pathological etiology and risk factors in patients with type two diabetes mellitus. HIV Nursing (Volume 22; issue 3).

36. Global Health 5050. COVID-19 sex-disaggregated data tracker. 2020. https:// globalhealth5050.org/covid19/sex-disaggregated-data-tracker. Accessed 10 Jul 2020.

37. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics ofcoronavirus disease 2019 in China. N Engl J Med. 2020; 382:1708–20.

38. Berletch JB, Yang F, Xu J, Carol L, Disteche CM. Genes that escape from Xinactivation. Hum Genet. 2011; 130:237–45. 24

39. Dalpiaz EL, Lamas AZ, Caliman IF, Ribeiro RF Jr, Abreu GR, Moyses MR, ET al.Correction: sex hormones promote opposite effects on ACE and ACE2 activity, hypertrophy and cardiac contractility in spontaneously hypertensive rats. PloS One. 2015; 10:e0133225.

40. Samson O. (2021).Thyroiditis After Receiving the AdenovirusVectored Vaccine for Coronavirus Disease (COVID19).). Cureus 13(6): e16045.

41. Jeeyavudeen MS; Patrick,AW.; Gibb,FW.; Dover,AR..(2021). COVID-19 vaccine-associated subacute thyroiditis: an unusual suspect for de Quervain's thyroiditis. BMJ Case Rep, 14:e246425.

42. Joob B.;Wiwanitkit V.(2021). Expected viscosity after COVID-19 vaccination, hyperviscosity and previous COVID-19 .Clin Appl Thromb Hemost, 27:1076.

43. Tamagna E.;Hershman J.;Premachandra BN.(1979).Circulating thyroid hormones in patient with hyperviscosity syndrome.Clin Chim Acta ,93:263-238.

44. Lania, A., Sandri, M. T., Cellini, M., Mirani, M., Lavezzi, E., & Mazziotti, G. (2020). Thyrotoxicosis in patients with COVID-19: the THYRCOV study. European journal of endocrinology, 183(4), 381387.

45. 45.Wei L, Sun S, Xu CH, Zhang J, Xu Y, Zhu H, Peh SC, Korteweg C, McNutt MA & Gu J. (2007).Pathology of the thyroid in severe acute respiratory syndrome. Human Pathology: 38 95–102.

46. Yao XH, Li TY, He ZC, Ping YF, Liu HW, Yu SC, Mou HM, Wang LH, Zhang HR, Fu WJ et al.(2020). A pathological report of three COVID19 cases by minimally invasive autopsies. Zhonghua Bing Li Xue Za Zhi : 49 E009.

47. Li MY, Li L, Zhang Y & Wang XS. (2020). Expression of the SARSCoV-2 cell receptor gene ACE2 in a wide variety of human tissues. Infectious Diseases of Poverty: 9 45.

48. Hoffmann M, Kleine-Weber H, Schroeder S, Kruger N, Herrler T, Erichsen S, Schiergens TS, Herrler G, Wu NH, Nitsche A et al. 25 (2020).SARSCoV-2 cell entry depends on ACE2 and TMPRSS2 and is blocked by a clinically proven protease inhibitor. Cell; 181 271:e8–280.e8.

49. Chung SM, Lee YY, Ha E, Yoon JS, Won KC, Lee HW, et al.(2020). The risk of diabetes on clinical outcomes in patients with coronavirus disease 2019: a retrospective cohort study. Dia- betes Metab J; 44:405-13.

50. Gregory JM, Slaughter JC, Duffus SH, Smith TJ, LeStour- geon LM, Jaser SS, et al. (2021).COVID-19 severity is tripled in the diabetes community: a prospective analysis of the pandem- ic's impact in type 1 and type 2 diabetes. Diabetes Care; 44:526-32.

51. Serban AL, Ferrante E, Carosi G, Indirli R, Arosio M, Man- tovani G.(2021). COVID-19 in Cushing disease: experience of a single tertiary centre in Lombardy. J Endocrinol Invest; 44:13356.