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ASSOCIATION THYROID FUNCTION TO PROGNOSIS OF COVID-19: THE SYSTEMATIC REVIEW

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ABSTRACT

Background: *Thyroid disorders have recently been associated with severity in patients with COVID-19, and experts have come together to discuss the association of this medical problem. Studying the relationship is suspected of helping manage the disease and also helps in the follow-up management process.*

Objectives and Methods: *To review the association between thyroid disease and COVID-19 from an extensive literature review. Data from Google Scholar with keywords "thyroid" and "covid" were collected, discussed, and analyzed to answer the following questions:*

- *How does the mechanism of thyroid disease affect Covid patients?*
- *How can thyroid disease make worsen the prognosis of COVID-19 after the infection has occurred?*
- *What is the medical management of thyroid disease in patients with COVID-19?*

Results: *There is evidence that the CoV-2 virus can induce non-permanent but reversible thyroid dysfunction, including thyroid disorders, namely subclinical and atypical thyroiditis. Patients with early thyroid disease are not at increased risk of contracting or transmitting SARS-CoV-2, and early thyroid dysfunction does not promote the worse progression of COVID-19. The presence of glucocorticoids and heparin, respectively, can affect thyroid hormone secretion and function, leading to the possibility of misdiagnosing thyroid dysfunction in severe cases of COVID-19.*

Conclusion: *SARS-CoV-2 can cause short-term thyroid dysfunction and is only reversible. Thyroid disease does not appear to affect the progression of COVID-19. Adequate management of patients with thyroid disease remains necessary during the pandemic.*

KEYWORDS: *COVID 19, Progression, Thyroid Dysfunction*

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INTRODUCTION

Coronavirus infection is a disease caused by Coronavirus. It causes the main symptoms of respiratory problems. The condition is in the spotlight because it is found the first time located in Wuhan, China. For the first time, the location of its appearance has made the COVID-19. Besides China, the Coronavirus also spread rapidly to various other countries, including Japan, Thailand, Japan, South Korea, and even the United States [13].

The cause of Coronavirus is a single-stranded RNA virus that comes from the Coronaviridae group—named Coronavirus because of its crown-shaped surface (crown/corona). Another virus that belongs to a similar group is the virus that caused Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV) several years ago. However, the Coronavirus from Wuhan is a new virus that has never been identified in humans before. Therefore, this virus is also referred to as the 2019 Novel Coronavirus or 2019-nCoV. Coronaviruses are commonly found in animals – such as camels, snakes, farm animals, cats, and bats. The virus can infect humans if there is a history of contact with these animals, such as farmers or traders in animal markets[15].

However, the explosion in the number of cases in Wuhan, China, shows that the Coronavirus can be transmitted from human to human. The virus can be transmitted through droplets, which are tiny water particles and usually come out when coughing or sneezing. If the droplets are inhaled or contacted with the eye corneal layer, a person is at risk for contracting this disease. Although Coronavirus can infect anyone, those who are elderly, have chronic conditions, and have low immune systems are more susceptible to this infection and its complications [20].

Coronavirus infection is generally known through the symptoms and physical examination that the patient complains about. After that, the doctor will perform several supporting reviews to help confirm the diagnosis. The supporting tests include complete blood count, blood clotting, kidney and liver function, and virological study. In addition, specimens from the patient's nose and pharynx (throat) will also be taken using a swabbing technique. Similarly, preparations of sputum and, if necessary, bronchial fluid (smaller airways) [14].

It can conclude the examination whether a virus or other causes cause the patient's illness. Meanwhile, the patient's blood plasma will also be examined to find the RNA of the Coronavirus. For radiological examinations, chest X-rays (x-rays) and chest CT scans may be performed. Most patients will show a picture of cloudiness in both lungs [19].

The relationship between the COVID-19 virus and the thyroid gland occurs in an immunomodulatory signaling mechanism with a complex hormone. The ties can be physiological, but some are pathological[19]. To determine the "thyroid biography" at a person's level is strongly influenced by the presence of a viral immune inflammatory response which will reveal lifelong thyroid function itself [3].

Thyroid hormones through genomic and nongenomic mechanisms function in signaling innate and adaptive immune responses[1]. Cytokine production and release are affected by physiological concentrations of L-thyroxine (T4) and 3,3',5-triiodo-L-thyronine (T3), and they are components of the "cytokine storm" that characterizes common systemic viral infections [4,5].

Thyroid hormone can carry out an antiviral action mechanism through an inflammatory mediator, namely IFN-γ[1]. Pathways through inflammatory cytokine mechanisms, hyperactivation of Th1 helper cell responses are part of an immune response against viral infections that can measure in the presence of thyroid disorders. Classic autoimmune thyroid disease, abbreviated as AITD, is a thyroid disease associated with interferon-alpha, checkpoint inhibitor-mediated thyroiditis, and alemtuzumab-induced thyroid function disturbances[3, 6-9].

Clinicians could prove that infection could be identified as an environmental stimulus that could accelerate the development of AITD. It can cause subacute thyroiditis [2,10]. Respiratory tract infections can trigger thyroid storms in patients with decompensated hyperthyroidism. It can ultimately increase the risk of infection-related death due to cardiovascular morbidity[11]. Research has also shown that T4 can activate human platelets[12] and maintain pathological

clotting encountered as a complication of viral infections. This hypothesis supports the relationship between the severity of COVID-19 and thyroid.

METHODS

This study is a comprehensive review of journal articles of reputed international journals using the search terms covid 19 and thyroid with no date and language restrictions published since June 20, 2021, and found a total of 106 articles but we focus in 5 articles (Flow chart 1). This review also contains several additional medical book literature for addition. The majority are public opinion regarding new strategies for treating thyroid patients in the face of the risk of COVID-19 transmission and the resulting surge in healthcare services [13-19].

We will provide an overview of the fundamental relationship between COVID-19 and the thyroid gland. We analyze how the pathomechanism has exacerbated the COVID-19 that has emerged so far.

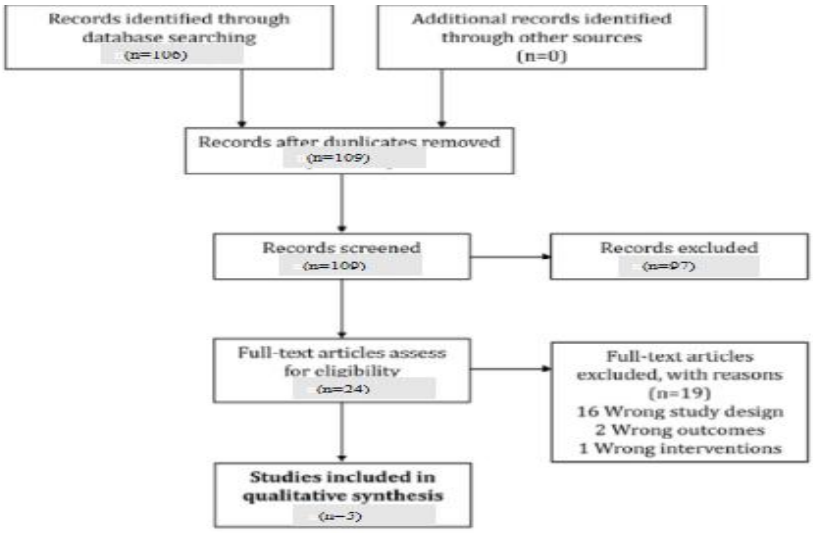

Figure 1: The Data Elimination

RESULTS

Table 1: Abnormality of the Thyroid in Covid 19 Patients

No	Journal Detail				Method	Clinical Finding	Outcome
	Author	Country	Population	Criteria Population			
1	Brancantella, 2020	Italy	1 Patient	18-year-old woman who came to our attention for fever, neck pain radiated to the jaw, and palpitations occurring 15 days after a SARS-CoV-2–positive oropharyngeal swab. Coronavirus disease 2019 (COVID-19) had been mild and the patient had completely recovered in a few days.	Case Study	At physical examination the patient presented with a slightly increased heart rate and a painful and enlarged thyroid on palpation. At laboratory exams free thyroxine and free triiodothyronine were high, thyrotropin undetectable, and inflammatory markers and white blood cell count elevated. Bilateral and diffuse hypoechoic areas were detected at neck ultrasound. One month earlier, thyroid function and imaging both were normal. We diagnosed Subacute Thyroiditis and the patient started prednisone. Neck pain and fever recovered within 2 days and the remaining symptoms within 1 week. Thyroid function and inflammatory markers normalized in 40 days.	This report the first case of Subacute Thyroiditis after a SARS-CoV-2 infection. We alert clinicians to additional and unreported clinical manifestations associated with COVID-19.
2	Tee LY, 2021	Singapore 265	1 Patient	A covid 19 patient complicated by Hashimoto's thyroiditis	Case Study	A 45-year-old Chinese man who lived in a dormitory with a COVID-19 outbreak presented with non-productive cough and rhinorrhoea for one day. On the second day of his symptoms, he was diagnosed with COVID-19 through a SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) reverse transcriptase-polymerase chain reaction test from a nasopharyngeal swab and admitted to a COVID-19 isolation ward. Seven days after the onset of a mild COVID-19 upper respiratory tract infection, he reported complete resolution of his respiratory symptoms but complained of acute-onset severe generalised fatigue and muscle weakness. He had no neck pain, constipation or weight gain. Before the symptoms began, he had been in good health and working full-time, and had not been taking any supplements or chronic medications. He had never smoked and was teetotal. He also denied any personal or family history of autoimmune or thyroid disease. On examination, the patient was afebrile and haemodynamically stable with no bradycardia or hypothermia. Cardiac, respiratory, abdominal and neurological examinations were unremarkable. The patient was clinically euthyroid with no goitre. Investigations were performed to determine the cause of his acute lethargy. His thyroid function test (TFT) showed an elevated thyroid-stimulating hormone (TSH) reading of 6.49 μIU/mL and a low free thyroxine (fT4) level of 9.19 pmol/L, which is typical of primary hypothyroidism. His thyroid peroxidase antibody levels exceeded the upper limit of detection (> 2,000 IU/mL), which was indicative of Hashimoto's thyroiditis. There was no anaemia, and electrolyte levels were normal. Inflammatory markers and creatinine kinase levels were not elevated, and the chest radiograph showed no consolidation or effusion. The patient was started on oral levothyroxine 25 mcg once a day and was counselled about his diagnosis of Hashimoto's thyroiditis. Five weeks later, the patient reported that he felt energised and had started running regularly. His TFT was still deranged but had improved (fT4 10.91 pmol/L, TSH 6.59 μIU/mL).	This is the first case of a patient who developed Hashimoto's thyroiditis after a COVID-19 infection. The time interval from the onset of his first respiratory symptoms to the inception of Hashimoto's thyroiditis was similar to that of reported cases of other autoimmune complications(1-4) and corresponds to the time frame of the cytokine storm.(5) It indicates that the hyperinflammatory state triggered by COVID-19 may predispose patients to develop autoimmune complications. This case reminds us to be vigilant of autoimmune diseases as possible complications of COVID-19, even in patients with mild COVID-19 infections.

3	Ippolito S, 2020	Italy	1 patient	A 69-year-old woman experienced mild fever, cough, and dyspnea during the recovery phase following back surgery.	Case Control Study	Medical therapy with hydroxychloroquine plus lopinavir/ritonavir and low-flow oxygen therapy were initiated as prescribed on hospital admission. No iodine-containing drugs were given. From day 5, the patient started complaining of palpitations, insomnia, and agitation, despite being afebrile and clinically stable. She had no neck pain. Thyroid function assessment showed suppressed serum thyroid-stimulating hormone (TSH: 0.08 mU/l, normal range 0.27–4.2) with increased serum-free thyroxine (FT4: 24.6 pg/ml, normal range 0.3–17) and free triiodothyronine (FT3: 5.5 pg/ml, normal range 2–4.4). TSH-receptor antibodies, thyroperoxidase, and thyroglobulin antibodies were all negative. Empirical therapy with methimazole was initiated. Five days later, thyrotoxicosis worsened (TSH 0.02 mU/l, FT4 29.7 pg/ml, FT3 5.6 pg/ml), and serum thyroglobulin was elevated (187 µg/l, normal range 3.5–77). Bedside thyroid ultrasound showed an enlarged hypoechoic thyroid, decreased vascularity and the known 30-mm homogeneous nodule in the right lobe (with peripheral vascularization). At thyroid scan using Tc 99-m, there was no uptake. Because NSAIDS could not be employed, methimazole was discontinued and steroids were given, starting with 40 mg intravenous methylprednisolone for 3 days, then continuing with 25 mg oral prednisone, to be progressively tapered over 4 weeks or more, according to clinical response [3]. Within a few days, symptoms markedly improved; 10 days after starting steroids, biochemical thyrotoxicosis substantially improved (FT4 21.9 pg/ml; FT3, 3.07 pg/ml). Of note, naso-pharyngeal control swab test for SARS-CoV-2 resulted positive 2 months after the first diagnosis, though respiratory symptoms were completely solved. Clinical presentation, ultrasound features, lack of thyroidal uptake, high serum thyroglobulin levels, and the absence of thyroid autoantibodies suggest a thyroid-destructive process compatible with a diagnosis of subacute (De Quervain's) thyroiditis, possibly triggered by SARS-CoV-2 infection. Neck pain was absent, but the patient was under high doses of painkillers after back surgery, possibly masking local symptoms. At differential diagnosis, we could not exclude painless thyroiditis, which, however, is less likely for epidemiological reasons and for the lack of thyroid autoimmunity.	We reported a case of subacute (destructive) thyroiditis during hospitalization for COVID-19, potentially related to SARS-CoV-2 infection, effectively treated by steroids. Physicians working in COVID-19 departments should be aware of possible connections between SARS-CoV-2 and thyroid dysfunction, which should be investigated by prospective studies.
4	Caron P,2020	France	-	This is narrative study	An understanding of the pathophysiological involvement of an abnormal pituitary-thyroid axis in SARS CoV-2 infection may enable correct interpretation of thyroid function test anomalies and accurate assessment of thyroid function, particularly in patients with severe forms requiring Emergency Room (ER) treatment, allowing appropriate management of thyroid dysfunctions, in particular thyrotoxicosis and thyroid insufficiency.	Diagnostic and/or therapeutic management of hypothyroidism during SARS-CoV-2 infection does not require any other particular consideration. Treatment of pre-existing hypothyroidism should be continued during COVID-19 infection. The patient should be provided with the necessary supplies of thyroid hormones in order to pursue treatment throughout lockdown. Levothyroxine dose should be increased by 30–50 % in case of pregnancy, and should be monitored according to clinical data and TSH concentration, specifically to prevent the development of hypothyroidism. Hydroxychloroquine treatment, alone or as part of a combined therapy [34] has been proposed as a treatment option for some COVID-19 patients. It may impair thyroxine metabolism and therefore requires TSH levels to be monitored to ensure euthyroidism is maintained [38], [39]. In practice, thyroid function needs to be assessed both clinically and hormonally, in the acute phase of a SARS-CoV-2 infection and during follow-up, in order to initiate levothyroxine replacement therapy if thyroid insufficiency is detected and to discontinue replacement therapy once pituitary gland disorders, in particular, resolve during convalescence	Based on the pathophysiology of SARS-CoV-2 infection in the pituitary-thyroid axis and a review of recent articles, we suggest routine assessment of thyroid function in the acute phase for COVID-19 patients requiring a high level of intensive care, as they frequently present thyrotoxicosis due to subacute thyroiditis related to SARS-CoV-2, and during convalescence in order to diagnose and adapt levothyroxine replacement treatment in patients with primary or central hypothyroidism. Considering the ongoing COVID-19 pandemic, future prospective studies are needed to increase epidemiological and clinical knowledge and optimize the management of thyroid disorders in COVID-19 patients.
5	Smulever A, 2020	Argentina	-	-	This is systematic review from some cases that occured	An appropriate thyroid hormone replacement therapy is suggested, to avoid immune dysfunction in patients with postoperative permanent hypothyroidism under non-suppressive therapy. we also postponed diagnostic FNAB and surgeries in our area where we have a more restrictive quarantine phase, otherwise, we recommend maintaining a regular decision-making process. In properly selected patients with suspected low-risk papillary thyroid carcinoma, active surveillance is strongly recommended as the first line of management. Surgery should be done with no delay in patients with rapidly progressing tumors, suspicion of anaplastic, or poorly differentiated carcinomas.	The COVID-19 outbreak changed life as we have never imagined. If it was so for persons with no associated disorders, the concerns that we have observed in our patients with a past personal history of thyroid cancer, and the hundreds of questions we have answered regarding the higher risk for a worse outcome of this infection in several conditions associated with thyroid cancer patients prompted us to write this short editorial. As we stated, several different situations should be considered in thyroid cancer patients that may give them a higher risk, but definitive data for these affirmations are not yet available. Therefore, the recommendations provided here remain dynamic and should be tailored according to the doubling rates for confirmed COVID-19 cases as well as the epidemiological circumstances for each region.

DISCUSSIONS

Relation between Thyroid and Covid-19

Relationship between Thyroid and COVID-19 SARS-CoV-2 uses ACE2 combined with transmembrane protease serine 2 (TMPRSS2) is a critical molecular complex to enter and infect host cells[4,5]. Expression levels of ACE2 and TMPRSS2 remain high in the thyroid gland and more than in the lung[5]. The in silico technique approach also described that thyroid ACE2 expression levels that were positively and negatively associated with immune system markers [CD8+ T cells, interferon responses, natural killer (NK) cells, and B cells in women and men, respectively, It could explain the different immune responses and the resulting different thyroid manifestations. The absorption by SARS-CoV-2 host cells is thought to involve proteases and other cellular molecules[4,5].

Integrins are central plasma membrane structural proteins that can be involved in SARS-CoV-2 cell invasion[1]. ACE2 binds to integrins to trigger their modulation of downstream signal transduction[5]. Finally, T4 regulates gene expression for monomeric proteins and forms integrins and thyroid hormones that promote integrin internalization[2,5]. Thus, thyroid hormone can positively affect the uptake of SARS-CoV-2 involving integrins[3].

TMPRSS2 and ACE2, peripheral olfactory receptor (OR) expression, have been demonstrated, including a broad expression profile in the thyroid gland[5]. Impaired OR signaling/function in the olfactory bulb or nasal neuro-epithelium is a molecular mechanism.

Thyroid Disease Make the Covid 19 Prognosis Worsen

The association of COVID-19 severity with low T3 syndrome is mainly due to a systemic inflammatory mechanism. Inflammatory mediators, exceptionally high levels of interleukins, especially IL-6, have recently been associated with a poorer prognosis of COVID-19 patients. IL-6 has been shown to affect suppressing the production of free levothyroxine (fT4) and free triiodothyronine (fT3). It proofs involved in the pathogenesis of low T3 syndrome. The research of Muller et al. recently revealed the presence of thyroid dysfunction in critically ill patients about the presence or absence of COVID-19 by comparing the data of hospitalized patients from 2019 to 2020. After excluding the history of thyroid dysfunction, the data obtained were lower serum TSH concentrations and lower serum TSH levels—Higher C-reactive protein in COVID-19 (2020) patients than in non-COVID-19 (2019) patients. Serum levels of FT4 are higher, and FT3 are similar among COVID-19 patients from critically ill non-COVID-19. The possible overlap between low T3 syndrome and thyroxine toxicosis caused by painful and atypical thyroiditis[20].

Management Thyroid Patients in Covid 19 Situation

There have been restrictions on public services in hospitals or clinics in several public policies lately. The number of thyroid fine-needle aspiration procedures is limited due to COVID-19-related healthcare restrictions[5]. Invasive services such as FNAB are modified so that the management of patients with thyroid disease is unknown[6]. Thus, controlling thyroid disease during a pandemic is necessary to prevent diagnostic and therapeutic delays, so the decision to postpone non-urgent measures can be safely postponed[7]. FNAB with cytologic assessment should be performed in patients at high risk of thyroid nodules without relevant delay[5]. Furthermore, patients requiring surgery for thyroid malignancies should undergo an adequate clinical assessment to prioritize interventions that cannot be delayed[8,9].

CONCLUSIONS

SARS-CoV-2 can cause short-term thyroid dysfunction and is only reversible. Thyroid disease does not appear to affect the progression of COVID-19. Adequate management of patients with thyroid disease remains necessary during the pandemic. Endocrine treatment centers and online consultations are needed to reduce the severity of these patients.

REFERENCES

1. *De Vito P, Incerpi S, Pedersen JZ, Luly P, Davis FB, Davis PJ. Thyroid hormones as modulators of immune activities at the cellular level.* Thyroid. *2011;21(8):879–90. doi: 10.1089/thy.2010.0429. [PubMed] [CrossRef] [Google Scholar]*
2. *Tomer Y, Davies TF. Infection, thyroid disease, and autoimmunity.* Endocr Rev. *1993;14(1):107–20. doi: 10.1210/edrv-14-1-107. [PubMed] [CrossRef] [Google Scholar]*
3. *Franceschi C, Ostan R, Mariotti S, Monti D, Vitale G. The aging thyroid: A reappraisal within the geroscience integrated perspective.* Endocr Rev. *2019;40(5):1250–70. doi: 10.1210/er.2018-00170. [PubMed] [CrossRef] [Google Scholar]*
4. *Shih CH, Chen SL, Yen CC, et al. Thyroid hormone receptor-dependent transcriptional regulation of fibrinogen and coagulation proteins.* Endocrinology. *2004;145(6):2804–14. doi: 10.1210/en.2003-1372. [PubMed] [CrossRef] [Google Scholar]*
5. *Davis PJ, Glinsky GV, Lin HY, Mousa SA. Actions of thyroid hormone analogs on chemokines.* J Immunol Res. *2016;2016:3147671. doi: 10.1155/2016/3147671. [PMC free article] [PubMed] [CrossRef] [Google Scholar]*
6. *Bartalena L, Brogioni S, Grasso L, Martino E. Interleukin-6 and the thyroid.* Eur J Endocrinol. *1995;132(4):386–93. doi: 10.1530/eje.0.1320386. [PubMed] [CrossRef] [Google Scholar]*
7. *Mazziotti G, Sorvillo F, Piscopo M, et al. Innate and acquired immune system in patients developing interferon-alpha-related autoimmune thyroiditis: A prospective study.* J Clin Endocrinol Metab. *2005;90(7):4138–44. doi: 10.1210/jc.2005-0093. [PubMed] [CrossRef] [Google Scholar]*
8. *Ferrari SM, Fallahi P, Galetta F, Citi E, Benvenga S, Antonelli A. Thyroid disorders induced by checkpoint inhibitors.* Rev EndocrMetabDisord. *2018;19(4):325–33. doi: 10.1007/s11154-018-9463-2. [PubMed] [CrossRef] [Google Scholar]*
9. *Scappaticcio L, Castellana M, Virili C, et al. Alemtuzumab-induced thyroid events in multiple sclerosis: A systematic review and meta-analysis.* J Endocrinol Invest. *2020;43(2):219–29. doi: 10.1007/s40618-019-01105-7. [PubMed] [CrossRef] [Google Scholar]*
10. *Nishihara E, Ohye H, Amino N, et al. Clinical characteristics of 852 patients with subacute thyroiditis before treatment.* Intern Med. *2008;47(8):725–9. doi: 10.2169/internalmedicine.47.0740. [PubMed] [CrossRef] [Google Scholar]*
11. *Akamizu T. Thyroid storm: A japaneseperspective.* Thyroid. *2018;28(1):32–40. doi: 10.1089/thy.2017.0243. [PMC free article] [PubMed] [CrossRef] [Google Scholar]*

12. *Davis PJ, Mousa SA, Schechter GP. New interfaces of thyroid hormone actions with blood coagulation and thrombosis.* Clin Appl ThrombHemost. *2018;24(7):1014–9. doi: 10.1177/1076029618774150. [PMC free article] [PubMed] [CrossRef] [Google Scholar]*

13. *Bartalena L, Chiovato L, Marcocci C, Vitti P, Piantanida E, Tanda ML. Management of graves' hyperthyroidism and orbitopathy in time of COVID-19 pandemic.* J Endocrinol Invest. *2020;43(8):1149–51. doi: 10.1007/s40618-020-01293-7. [PMC free article] [PubMed] [CrossRef] [Google Scholar]*

14. *Boelaert K, Visser WE, Taylor PN, Moran C, Léger J, Persani L. Endocrinology in the time of COVID-19. Management of hyperthyroidism and hypothyroidism. Eur J Endocrinol. 2020;183(1):G33-9. 10.1530/EJE-20-0445. [PMC free article] [PubMed]*

15. *Dworakowska D, Grossman AB. Thyroid disease in the time of COVID-19.* Endocrine. *2020;68(3):471–4. doi: 10.1007/s12020-020-02364-8. [PMC free article] [PubMed] [CrossRef] [Google Scholar]*

16. *Pal R, Banerjee M. COVID-19 and the endocrine system: Exploring the unexplored.* J Endocrinol Invest. *2020;43(7):1027–31. doi: 10.1007/s40618-020-01276-8. [PMC free article] [PubMed] [CrossRef] [Google Scholar]*

17. *Vrachimis A, Iakovou I, Giannoula E, Giovanella L. Endocrinology in the time of COVID-19. Management of thyroid nodules and cancer. Eur J Endocrinol. 2020;183(1):G41-8. 10.1530/EJE-20-0269. [PMC free article] [PubMed]*

18. *Mehanna H, Hardman JC, Shenson JA, et al. Recommendations for head and neck surgical oncology practice in a setting of acute severe resource constraint during the COVID-19 pandemic: An international consensus.* Lancet Oncol. *2020;21(7):e350–9. doi: 10.1016/S1470-2045(20)30334-X. [PMC free article] [PubMed] [CrossRef] [Google Scholar]*

19. *Li M, Marquez RC, Vinales KL, et al. Considerations for Thyroid Fine Needle Aspiration (FNA) biopsies during the COVID-19 pandemic. Clin Thyroidology. 2020:156–8. 10.1089/ct.2020;32.156-158.*

20. *Muller I et al (2020) Atypical thyroiditis associated with SARS-CoV-2. Lancet Diab Endocrinol 8:739–741[PMC free article] [PubMed] [CrossRef] [Google Scholar]*