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Adverse Events Associated with COVID-19 Vaccination in Adolescents with Endocrinological Disorders: A Cross-Sectional Study

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What is already known on this topic?

Adverse events associated with Coronavirus disease-2019 (COVID-19) vaccination in healthy adolescents are mostly similar to those in adults. There is a need for knowledge about the safety and adverse events of COVID-19 vaccines in special patient groups.

What this study adds?

We showed that the incidence and severity of adverse event associated with COVID-19 vaccination in adolescents with endocrinological disorders were similar to healthy subjects. Autoimmune and non-autoimmune endocrine disorders had similar side effect profiles after COVID-19 vaccines. Treatment agents for endocrinological diseases did not cause a difference in the incidence of adverse events.

Abstract

Objective: The aim was to evaluate the adverse events seen after Coronavirus disease-2019 (COVID-19) vaccination in pediatric patients with diagnosed endocrinological problems and to compare them with healthy controls.

Methods: In this cross-sectional study, patients aged 12-18 years who attended a single department between January and May 2022 and were followed up for at least six months due to endocrine diseases, and healthy subjects in the same age group, all of whom had received a COVID-19 vaccine [BNT162b2 mRNA or inactivated vaccine] were included. Adverse events experienced after the vaccination were evaluated by questionnaire.

Results: A total of 160 subjects (85 patients, 75 healthy controls) with a median (25-75p) age of 15.5 (14.1-16.9) years were included. The frequency of adverse events was higher in those vaccinated with the mRNA vaccine compared to the inactivated one after the first dose ($p = 0.015$). The incidence of adverse events observed after the first and second doses of both COVID-19 vaccines was similar in the patient and control groups ($p = 0.879$ and $p = 0.495$, respectively), with local reactions being the most common. The frequency of adverse events was similar among the patients who did or did not receive any endocrinological treatment ($p > 0.05$). The incidence and severity of systemic reactions were similar to those in healthy subjects for both vaccine doses, regardless of the underlying diagnosis, autoimmunity state, or treatment regimen used in patients with endocrine diseases.

Conclusion: The incidence and severity of adverse events associated with COVID-19 vaccinations in adolescents with endocrinological disorders were similar to healthy subjects, in the early post-vaccination period.

Keywords: Coronavirus, vaccination, endocrine, pandemic, pediatrics

Introduction

The whole world has been impacted by the Coronavirus disease-2019 (COVID-19) pandemic, which has lasted more than three years at the time of writing, caused by the newly identified member of the coronavirus family, Severe acute respiratory syndrome-Coronavirus-2 (SARS-CoV-2) (1). Since there is no effective treatment, mass national vaccination

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programs have been used widely in an attempt to control the pandemic. Therefore, vaccine studies have come to the fore and vaccines that are reported to be effective against the disease have begun to be used (2,3).

Although COVID-19 generally has a milder clinical course in the pediatric population, it may have a severe course in any age group and serious complications, such as multi-system inflammatory syndrome in children, have been observed in this age group (4,5). Therefore, the necessity of initiating an effective vaccination program in children arose, and after studies focusing on this subject, the use of COVID-19 vaccines in children aged 12 years and older was initially approved. Adverse events seen with these vaccines in adolescents are mostly similar to those in adults, though several serious events, including myocarditis, were reported and raised concerns about the use of these vaccines in this age group (6,7,8). Furthermore, these findings were largely reported in patients who were healthy prior to COVID-19, and the side effect profile of these vaccines in children and adolescents with chronic diseases is not yet known.

Given the systemic function of hormones, questions were raised about the effects and side effects of COVID-19 vaccines in patients with endocrine disorders and several reports commented on this topic (9,10,11,12). In addition, there were concerns that autoimmunity, which may be the etiology in a number of endocrine diseases, may also change the response to COVID-19 and the vaccines. However, vaccination recommendations similar to those made for the healthy population were made for patients who were not on conventional immunosuppressants, high-dose glucocorticoids, or immunomodulatory treatments, such as biological agents, for a systemic autoimmune disease (13). Unfortunately, the evidence to support these recommendations are mainly based on adult studies and there is no data regarding the safety and adverse events of COVID-19 vaccines in children and adolescents with endocrine diseases or who were under treatment for these diseases.

In this study, the aim was to investigate the adverse events observed after COVID-19 vaccination with either inactive SARS-CoV-2 or BNT162b2 messenger RNA (mRNA) COVID-19 in use in our country in adolescents with endocrinological disorders and to compare these results with healthy subjects.

Methods

This cross-sectional study was conducted in a single center between January and May 2022. Patients aged 12-18 years who attended the pediatric endocrinology department and who had been followed up for at least six months for an endocrinological disorder were included. Patients with any other underlying diseases, syndromes, or a history of drug use for non-endocrinological disorders were excluded. Obesity was defined in patients with exogenous obesity by a body mass index above the 95th percentile, and those with any underlying non-endocrinological causes of obesity were also excluded. The control group consisted of healthy adolescents in the same age group without any acute or chronic disease, who attended outpatient clinics for routine check-ups. The main inclusion criterion for both groups was to be vaccinated against SARS-CoV-2. The medical history of the patients was confirmed by medical records and the vaccination status of all participants was verified by national registries. Individuals whose verification failed or whose medical records could not be accessed were not included in the study.

All patients and healthy controls were vaccinated with at least one dose of one of the COVID-19 vaccines. Information about the type of vaccine and the adverse events after vaccinations were gathered using a questionnaire, that was answered during a routine outpatient visit. In our country, two types of vaccines against SARS-CoV-2, namely inactivated vaccine and BNT162b2 mRNA, became available for all children older than 12 years in September 2021. Individuals were free to choose their vaccine types and both vaccines were administered in two doses with a one-month interval.

Adverse events after vaccinations were evaluated by the Pediatric Infectious Disease department, based on the recommendations made by the Vaccine Adverse Event Reporting System administered by the Food and Drug Administration and Centers for Disease Control and Prevention (14). Criteria include, redness, warmth, pain, or tenderness at the injection site that was defined as a local reaction. Events causing permanent sequelae, life-threatening issues, or requiring hospitalization were classified as serious adverse events. Other remaining reactions, such as fever, rash, and/or joint pain, were classified as non-serious systemic adverse events.

Ethics

The Dokuz Eylül University Local Ethics Committee of the host institute approved the study (ethics approval number: 2022/05-08, date: 09.02.2022), and the study was performed in accordance with the principles of the Declaration of Helsinki. Informed written consent was provided by each patient and his/her parents before participating in the study.

Statistical Analysis

All statistical analyses were performed using Statistical Package for the Social Sciences for Windows, version 24.0

(IBM Inc., Armonk, NY, USA). The distribution of data was evaluated with the Kolmogorov-Smirnov test and the data are presented as number (%) for categorical variables, and median (25^{th}-75^{th} percentile) for numerical variables. Comparisons were performed using the Pearson chi-square test and the Fisher exact for categorical variables and the Student's t-test or the Mann-Whitney U test for continuous variables, as appropriate. The McNemar test was used to compare the categorical data of two related groups. A p value of < 0.05 was considered statistically significant.

Results

A total of 160 subjects (85 patients, 75 healthy controls) were included in the study, 56.3% of whom were girls. The median age of patients was 15.5 (14.1-16.9) years. Groups were similar in terms of age and gender (p = 0.185 and p = 0.563, respectively). Subjects were included after a median of 5 (5-6) months from the first dose of vaccination. Endocrinological diagnoses in the patient group were: type 1 diabetes (41.1%, n = 35); obesity (18.8%, n = 16); hypothyroidism (17.6%, n = 15); hypopituitarism (5.9%, n = 5); polycystic ovarian syndrome (4.7%, n = 4); autoimmune polyglandular syndrome type 2 (3.5%, n = 3); hyperthyroidism (2.4%, n = 2); pubertal disorders (2.4%, n = 2); congenital adrenal hyperplasia (2.4%, n = 2); and prolactinoma (1.2%, n = 1). In total, 48 patients (56.5%) had an autoimmune disease. Sixty-three (74.1%) of the patients were receiving treatment for endocrine disorders. The most commonly used treatments were insulin (43.5%), levothyroxine (20%), and hydrocortisone (4.7%).

One hundred and fifty individuals (93.8%) were vaccinated with BNT162b2 mRNA (77 patients, 73 controls), and the remainder (6.2%, n = 10) with the inactivated vaccine (eight patients, two controls) for the first dose. The frequency of adverse events was higher in those vaccinated with the mRNA vaccine compared to the inactivated vaccine (p = 0.015), but it was similar among the patient and control groups regardless of vaccine type (p = 0.879; Table 1). Both groups experienced local events as the most common side effect of the first dose of COVID-19 vaccines (p = 0.634). In terms of systemic symptoms, fatigue, myalgia, and fever were the most common findings and the rate of all systemic events was not different between the two groups (p = 0.763) (Table 1). Sixteen subjects in the patient and control groups (30.2% and 35.6%, respectively) suffered both local and systemic symptoms (p = 0.692). Three individuals (one patient with hypothyroidism, one with obesity, and a healthy control) needed admission to hospital, classified as a severe reaction, because of symptoms after the first dose. All of them had fever and the one with obesity also had vomiting.

One hundred and forty-six individuals (77 patients, 69 healthy controls) completed the vaccination schedule with a second dose. The BNT162b2 mRNA vaccine was given to 138 subjects (70 patients, 68 controls) and the inactivated vaccine was administered to eight (seven patients, one control). Although there was a higher incidence of side effects with the second dose of the mRNA vaccine than with the inactivated vaccine, this was not significant (p = 0.053). The frequency of adverse events was again similar after the second dose of vaccine in both adolescents with endocrinological problems and healthy subjects (p = 0.495). As with the first doses, the most common complaint was local reactions after the second dose (p = 0.919). The rate of systemic events did not significantly differ between the two groups (p = 0.958) (Table 2). Eighteen patients (36.7%) and 15 (33.3%) controls experienced both systemic and local reactions (p = 0.813). One patient with obesity (because of myalgia and a severe local reaction) and two healthy adolescents (because of fever, myalgia, and vomiting) were admitted to hospital after the second dose. There was no difference in the incidence of adverse events between the patient and control groups for each dose of each vaccine type (p > 0.05) (Figure 1). The distribution of these events observed after each vaccination is given in Table 3.

Table 1. The comparison of the two groups regarding the findings of the first dose administration of Coronavirus disease-2019 vaccines

	Patient group (n = 85)	Control group (n = 75)	p
Age (years)	15.1 (13.9-17.0)	16.0 (14.7-16.8)	0.182
Female [n (%)]	46 (54.1%)	44 (58.7%)	0.563
BNT162b2 mRNA vaccine [n (%)]	77 (51.3%)	73 (48.7%)	0.105
Adverse event incidence [n (%)]	52 (61.2%)	45 (60.0%)	0.879
Local reactions [n (%)]	32 (37.6%)	31 (41.3%)	0.634
Systemic reactions [n (%)]	36 (42.4%)	30 (40.0%)	0.763
Both local and systemic reactions [n (%)]	16 (30.2%)	16 (35.6%)	0.692
Severe adverse events [n (%)]	2 (2.4%)	1 (1.3%)	1.000

Table 2. Comparison of patient and healthy control groups after the second dose of Coronavirus disease-2019 vaccines

	Patient group (n = 77)	Control group (n = 69)	p
Age (years)	15.1 (13.8-17.0)	16.0 (14.7-16.8)	0.132
Female [n (%)]	43 (55.8%)	38 (55.1%)	0.925
BNT162b2 mRNA vaccine [n (%)]	70 (90.9%)	68 (98.6%)	0.066
Adverse event incidence [n (%)]	46 (59.7%)	45 (65.2%)	0.495
Local reactions [n (%)]	33 (42.9%)	29 (42.0%)	0.919
Systemic reactions [n (%)]	34 (44.2%)	31 (44.9%)	0.925
Both local and systemic reactions [n (%)]	18 (23.4%)	15 (21.7%)	0.813
Severe adverse events [n (%)]	1 (1.3%)	2 (2.9%)	0.603

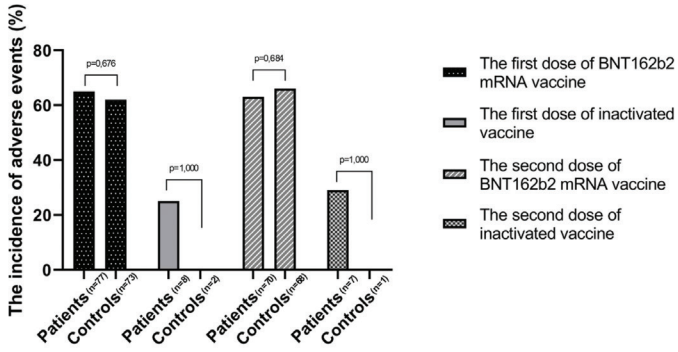

Figure 1. The incidence of adverse events after each type and dose of Coronavirus disease-2019 vaccine in the patient and control groups

Table 3. The distribution of adverse events observed after Coronavirus disease-2019 vaccines

Adverse events	The first dose of the BNT162b2 mRNA vaccine		The first dose of the inactivated vaccine		The second dose of the BNT162b2 mRNA vaccine		The second dose of the inactivated vaccine	
	Patients (n = 77)	Controls (n = 73)	Patients (n = 8)	Controls (n = 2)	Patients (n = 70)	Controls (n = 68)	Patients (n = 7)	Controls (n = 1)
Local reactions	31 (40.3%)	31 (42.5%)	1 (12.5%)	0 (0%)	32 (45.7%)	29 (42.6%)	1 (14.3%)	0 (0%)
Fever	13 (16.9%)	8 (11.0%)	1 (12.5%)	0 (0%)	13 (18.6%)	11 (16.2%)	1 (14.3%)	0 (0%)
Myalgia	14 (18.2%)	15 (20.5%)	1 (12.5%)	0 (0%)	11 (15.7%)	15 (22.1%)	2 (28.6%)	0 (0%)
Fatigue	16 (20.8%)	15 (20.8%)	2 (25.0%)	0 (0%)	14 (20.0%)	20 (29.4%)	0 (0%)	0 (0%)
Sore throat	2 (2.6%)	3 (4.1%)	0 (0%)	0 (0%)	3 (4.3%)	3 (4.4%)	0 (0%)	0 (0%)
Headache	7 (9.1%)	4 (5.5%)	0 (0%)	0 (0%)	1 (1.4%)	4 (5.9%)	0 (0%)	0 (0%)
Arthralgia	5 (6.5%)	4 (5.5%)	1 (12.5%)	0 (0%)	2 (2.9%)	2 (2.9%)	1 (14.3%)	0 (0%)
Cough	3 (3.9%)	2 (2.7%)	0 (0%)	0 (0%)	3 (4.3%)	1 (1.5%)	0 (0%)	0 (0%)
Vomiting	3 (3.9%)	1 (1.4%)	0 (0%)	0 (0%)	2 (2.9%)	2 (2.9%)	0 (0%)	0 (0%)
Abdominal pain	1 (1.3%)	0 (0%)	0 (0%)	0 (0%)	1 (1.4%)	0 (0%)	0 (0%)	0 (0%)
Diarrhea	1 (1.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Rash	0 (0%)	2 (2.7%)	0 (0%)	0 (0%)	0 (0%)	1 (1.5%)	0 (0%)	0 (0%)
Hyperglycemia	7 (9.1%)	0 (0%)	1 (12.5%)	0 (0%)	4 (5.7%)	0 (0%)	0 (0%)	0 (0%)
Hypoglycemia	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1.4%)	0 (0%)	0 (0%)	0 (0%)
Menstrual irregularity	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1.5%)	0 (0%)	0 (0%)
Chest pain	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1.4%)	0 (0%)	0 (0%)	0 (0%)

When the patients were grouped by the presence of autoimmunity as part of their disease or not, the incidence of side effects did not differ between these patient subgroups for each dose of the vaccine (Table 4). Also, the frequency of adverse events was similar after either the first or second doses of vaccines between patients with and without treatment for the underlying endocrine diagnosis ($p > 0.05$). When the patients with or without autoimmune disorders and who only received the mRNA vaccine ($n = 77$) were compared, the incidence of adverse events was similar after both doses ($p = 0.896$ and $p = 0.955$ for the first and second doses, respectively). In addition, the frequency of local and systemic reactions was similar between these two groups after either dose of the mRNA vaccine ($p > 0.05$).

In children with endocrinological problems, 70.5% of those who experienced side effects after the first dose also reported adverse events after the second dose ($p = 0.851$). Eight patients with type 1 diabetes experienced hyperglycemia after the first dose, four experienced hyperglycemia after the second dose, and one patient had hypoglycemia after the second dose. Detailed information on symptoms after each dose of COVID-19 vaccine in the patient group according to underlying diagnosis is presented in Figure 2. The incidence of side effects was similar after either vaccine dose, regardless of the treatment agents used in patients with endocrine disorders ($p > 0.05$).

Discussion

Several types of COVID-19 vaccines were produced rapidly, with mRNA and inactivated types as the most commonly used vaccines. These vaccines were administered in adults initially and, after safety approvals, vaccination schedules for adolescents and children were launched (2,3). While the most frequently reported adverse event was local reactions at the vaccination site, systemic symptoms including fatigue, headache, myalgia, and fever were also commonly reported. Moreover, the incidence of side effects after vaccination was reported to be higher with mRNA vaccines than with the inactivated type (15,16). The results of the present study confirm that the most common adverse event was a local reaction in both patient and control groups after COVID-19 vaccines. Thus, there was a higher rate of complaints after the first dose of the mRNA vaccine than with the inactivated type. It should be noted that there were very few subjects in the inactivated vaccine group, which may have skewed our results. Published evidence in this field is largely derived from studies in adult age groups and initial results of vaccination studies in adolescents supported the safety of COVID-19 vaccines (6). However, more serious complications, such as myocarditis and pericarditis, have also been reported in adolescents (7,8). The frequency of adverse events in the early post-vaccination period was reported to be as high as 60%, although most were local events in pediatric studies (17,18,19). All these data were obtained from previously healthy children, and the side-effect profile of these vaccines

Table 4. Comparison of patients with endocrine disorders stratified by the presence of an autoimmune mechanism in the condition or not

		Autoimmune diseases (n = 48)	**Non-autoimmune diseases (n = 37)**	**p**
Age (years)		14.9 (13.9 – 17.0)	15.2 (13.8 – 17.1)	0.940
Female [n (%)]		28 (58.3%)	18 (48.2%)	0.374
The first dose (n = 85)	BNT162b2 mRNA vaccine [n (%)]	42 (87.5%)	35 (94.6%)	0.457
	Adverse event incidence [n (%)]	29 (60.4%)	23 (62.2%)	0.870
	Local reactions [n (%)]	16 (33.3%)	16 (43.2%)	0.350
	Systemic reactions [n (%)]	22 (45.8%)	14 (37.8%)	0.460
	Both local and systemic reactions [n (%)]	9 (18.8%)	7 (18.9%)	0.984
	Severe adverse events [n (%)]	0 (0%)	2 (5.4%)	0.187
		Autoimmune diseases (n = 43)	**Non-autoimmune diseases (n = 34)**	**p**
The second dose (n = 77)	BNT162b2 mRNA vaccine [n (%)]	38 (88.4%)	32 (94.1%)	0.455
	Adverse event incidence [n (%)]	25 (58.1%)	21 (61.8%)	0.747
	Local reactions [n (%)]	17 (39.5%)	16 (47.1%)	0.508
	Systemic reactions [n (%)]	20 (46.5%)	14 (41.2%)	0.640
	Both local and systemic reactions [n (%)]	9 (20.9%)	9 (26.5%)	0.568
	Severe adverse events [n (%)]	0 (0%)	1 (2.9%)	0.442

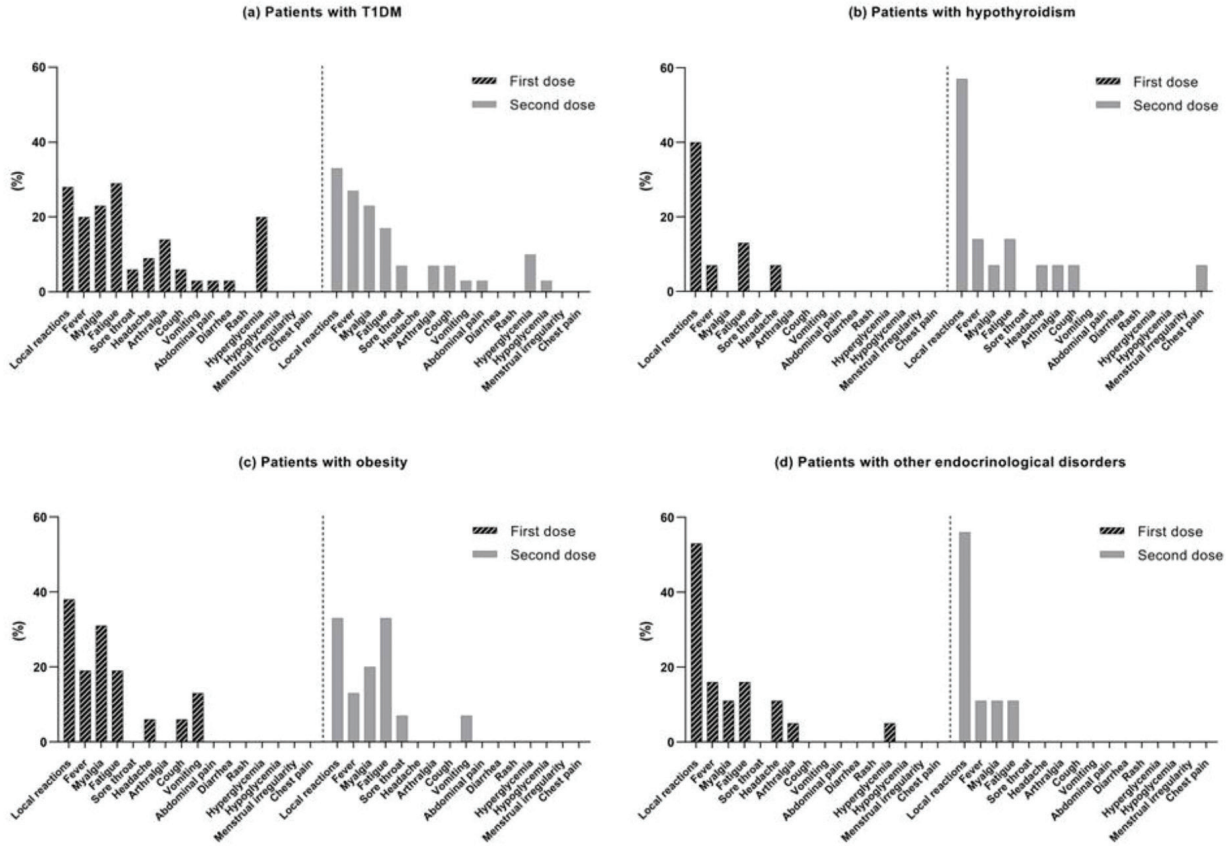

Figure 2. The distribution of adverse events after each dose of Coronavirus disease-2019 vaccine in the patient group, stratified by underlying diagnosis; (a) patients with T1DM, (b) patients with hypothyroidism, (c) patients with obesity, (d) patients with other endocrinological disorders

T1DM: type 1 diabetes mellitus

in pediatric patients with chronic diseases is unclear. The results of the present study are comparable with these earlier reports, showing a similar adverse event incidence after COVID-19 vaccines in patient and control groups. It also appears that experiencing an adverse events after the first dose did not affect the frequency of experiencing an event after the second dose of COVID-19 vaccines in patients with endocrinological disorders.

The endocrine system was thought to be affected by COVID-19 vaccines (11,12). However, the overall benefits of COVID-19 immunization were accepted to outweigh the risk of adverse events. Nevertheless, questions are still unresolved regarding the frequency of COVID-19 vaccine-related side effects in patients with an endocrinopathy (12). In addition to the adverse events seen in the general population, further complications, such as interstitial lung disease, have been reported in several patients with autoimmune diseases, particularly after the inactivated vaccine. In addition, exacerbation of the underlying disease has been an important consequence of COVID-19 vaccination (13). In light of this information, concerns arose about whether COVID-19 vaccines cause different and severe adverse events in children and adolescents with chronic diseases. In a recent study, Haslak et al. (20) found a similar safety and side-effect profile of COVID-19 vaccines in adolescents with rheumatological diseases, including autoimmune ones, compared to healthy controls. They reported a rate of adverse events of approximately 40%, which were observed more frequently with the mRNA-type vaccine. Their results showed that adverse events in adolescents with chronic diseases were commonly mild, such as fatigue, myalgia, and reaction at the vaccine site, regardless of the underlying disease or treatment regimens (20). The present study found similar results with a similar adverse event profile and severity in adolescents with endocrinological disorders. The patient group did not have a different frequency of side effects in the early post-vaccination period compared with healthy controls. In addition, an autoimmune element of the endocrinopathy had no effect on the incidence of events after the first or second dose of vaccines. This finding suggests that autoimmune disorders as part of one of the

endocrinopathies included in this study and not treated by immunomodulatory drugs, result in similar immune reactions as seen in non-autoimmune conditions. However, further molecular and clinical studies should focus on this issue, investigating the possible effects of these vaccines on autoimmunity and autoimmune diseases. The distribution of complaints varied among patients regarding underlying diagnoses, such as glycemic changes in some diabetic individuals. This may be due to the fact that inflammatory responses influence insulin sensitivity, causing a fluctuation in blood glucose levels, but also by the individual variabilities in glycemic controls of patients with diabetes.

Despite the generally good safety record of vaccines, a small number of reported severe complications, such as acute respiratory failure, sensorineural hearing loss, myocarditis, or thromboembolic events after COVID-19 vaccines, especially with the mRNA type, are reported to have increased patient hesitancy regarding immunization programs (21,22,23,24). However, we found that endocrine diseases did not increase the incidence of severe reactions requiring hospitalization in either vaccine type or at first or second dose. This finding was similar to a previous report showing severe reactions in only two of 223 adolescents with rheumatological problems who received the mRNA vaccine (20). Hence, the results of the present study add to the evidence suggesting a good safety profile for COVID-19 vaccines in adolescents with endocrinological disorders. It should be noted that the adverse event profile was only relevant for the early period after vaccination and there is a need for studies to evaluate the long-term side effects, and also to show the efficacy of these vaccines by investigating immune response or antibody levels in specific patient groups.

Routine childhood vaccines are generally regarded as being safe in children with endocrine disorders (25,26). In particular, steroids are known to alter the immune system and immunological reactions, and conflicting results about adverse events of these vaccines under steroid treatment were reported recently (27,28). Some authors reported a history of steroid intake as a predictor of adverse reactions, but short-term and low-dose corticosteroid use was shown to reduce reactogenicity after COVID-19 vaccines in another study (29,30). Yet, there is no evidence that hormone replacement therapies reduce the efficacy of COVID-19 vaccines or increase adverse side effects. The present study showed that adverse events did not differ among treated or untreated patients with endocrinological disorders. Furthermore, none of the patients on hydrocortisone replacement for adrenal insufficiency had a severe reaction. This may be due to the use of physiological dosing for replacement of endogenous hormones in these patients. It was suggested that patients with endocrinological problems should be included in the routine vaccination programs, but they should be followed closely in terms of complications that may develop specific to the disease (10). Some suggestions were made for these patients, such as close blood glucose monitoring in diabetic individuals, additional insulin dose administration when necessary, or increasing the steroid replacement dose in patients with adrenal insufficiency when fever and serious side effects develop. All these recommendations were based on data from adult patients, and the present study in adolescents supports these reports. For example, some of our patients with diabetes had hyperglycemia or hypoglycemia within the early period after COVID-19 vaccination. Both the results of the present study and published evidence indicate the importance of a patient-based, individualized approach after the administration of COVID-19 vaccines in patients with endocrinological problems.

Study Limitations

The main strength of our study was that this is the first study to investigate early adverse events after COVID-19 vaccination in adolescents with endocrinological disorders. Nevertheless, there are notable limitations. First of all, data were collected by questionnaire for past events, which is subject to patient/family recall bias. However, most of the studies into drug/vaccine adverse events use similar methods. Another limitation was that our patient group was not homogenous and we could not evaluate the duration or dosage of the treatment regimens for endocrine diseases. Also, the history of COVID-19 infection before vaccination was unknown but the regulations in our country did not permit COVID-19 vaccination within six months of a known infection. Finally, the low number of individuals in subgroup analyses lessen the reliability of these results. In this regard there was a notably small group size for the inactivated vaccine group, especially for healthy controls, which may influence any comparison with this subgroup. Therefore, there is a need for prospective studies in this field with larger cohorts to clearly elucidate the potential complications of COVID-19 vaccines in such special patient groups.

Conclusion

The incidence and severity of adverse events after either inactivated or mRNA COVID-19 vaccines in our country were similar between adolescents with endocrinological disorders and healthy subjects. Adverse events were more frequent after the mRNA vaccine compared to the inactivated one, but the most common complaint was local

reactions with both vaccine types. Endocrine disorders with or without an autoimmune element had similar side effect profiles. Treatment agents for endocrine diseases did not appear to cause a difference in the incidence of adverse events. However, patients should be informed and followed closely for disease-specific complications.

Ethics

Ethics Committee Approval: The Dokuz Eylül University Local Ethics Committee of the host institute approved the study (ethics approval number: 2022/05-08, date: 09.02.2022).

Informed Consent: Informed written consent was provided by each patient and his/her parents before participating in the study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: İbrahim Mert Erbaş, İrem Ceren Erbaş, Gözde Akın Kağızmanlı, Kübra Yüksek Acinikli, Özge Besci, Korcan Demir, Ece Böber, Nurşen Belet, Ayhan Abacı, Concept: İbrahim Mert Erbaş, İrem Ceren Erbaş, Ayhan Abacı, Design: İbrahim Mert Erbaş, İrem Ceren Erbaş, Ayhan Abacı, Data Collection or Processing: İbrahim Mert Erbaş, İrem Ceren Erbaş, Gözde Akın Kağızmanlı, Kübra Yüksek Acinikli, Özge Besci, Korcan Demir, Ece Böber, Nurşen Belet, Ayhan Abacı, Analysis or Interpretation: İbrahim Mert Erbaş, İrem Ceren Erbaş, Gözde Akın Kağızmanlı, Kübra Yüksek Acinikli, Özge Besci, Korcan Demir, Ece Böber, Nurşen Belet, Ayhan Abacı, Literature Search: İbrahim Mert Erbaş, İrem Ceren Erbaş, Gözde Akın Kağızmanlı, Kübra Yüksek Acinikli, Özge Besci, Korcan Demir, Ece Böber, Nurşen Belet, Ayhan Abacı, Writing: İbrahim Mert Erbaş, İrem Ceren Erbaş, Ayhan Abacı.

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