Mucocutaneous presentations of consultant critical and non-critical cases of admitted COVID-19 patients, outpatients, and vaccine-associated dermatoses: a clinical atlas and a large original study of two general COVID-19 centers from Iran

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Key words: mucocutaneous, dermatology, mucosa, COVID-19, vaccine, atlas.

Contributions: the authors contributed equally to the data preparation and finalization of this article. All images have been taken by the authors of this article and are personal data.

Conflict of interest: the authors declare no conflict of interest, and all authors confirm accuracy.

Ethics approval and consent to participate: this study was approved by the Ethics Committee of the Iran University of Medical Sciences

Patient consent for publication: written informed consent was obtained from the patients for the publication of this manuscript and any accompanying images. To keep ethical principles, the name of the patient was not pointed out in the paper.

Availability of data and materials: the data supporting the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: the authors would like to thank staff of Rasool Akram Medical Complex Clinical Research Development Center specially Mrs Farahnaz Nikkhah for their technical and editorial assistance.

Received for publication: 10 January 2022.
Accepted for publication: 20 January 2022.
Early view: 23 May 2022.

Dermatology Reports 2023; 15:9473
doi:10.4081/dr.2023.9473

Abstract

Rapid and proper diagnosis of mucocutaneous presentations of COVID-19 which in many cases are representing internal organ damage is a key way to better approach these patients, and it could be even lifesaving. In this original study, we reported consultant critical and non-critical cases of admitted COVID-19 patients and some interesting outpatient cases for 14 months, and some newly encountered vaccine-associated dermatoses. We presented 121 cases divided into 12 categories; all had full multi-aspects photographs attached as an atlas to a *Supplementary File*. These categories were:1- Generalized papulopustular eruptions (3 patients), 2- Erythroderma (4 patients), 3- Maculopapular lesions(16 patients), 4- Mucosal lesions (8 patients), 5- Urticarial lesions and angioedema (16 patients), 6- Vascular injuries (22 patients), 7- Vesiculobullous lesions (12 patients), 8- The specific new onset of mucocutaneous presentations or aggravation of any especial previous dermatoses (9 patients), 9- Nail changes (3 patients), 10- Hair loss (2 patients), 11- Non-specific mucocutaneous problems (16 patients) and 12-Vaccine-associated dermatoses (10 patients).In the pandemic, if we countered with extensive mucocutaneous lesions with vascular components or vesiculobullous erosive lesions in association with any cutaneous rash that could be an alarming sign of a probable life-threatening systemic event, we would need to approach them as soon as possible.

Background

What is known?

Recognition of various types of mucocutaneous presentations of COVID-19, especially in admitted critical cases, is of great importance for dermatologists and non-dermatologist practitioners to improve patient management. Proper diagnosis could be even lifesaving in certain cases, such as those of patients with potentially life-threatening drug eruptions or purpura fulminans. Although COVID-19-associated mucocutaneous reactions have been studied frequently, knowledge about these eruptions after COVID-19 vaccination is still limited.

What does this study add?

Generalized papulopustular eruptions, erythroderma, maculopapular lesions, mucosal lesions, urticarial lesions and angioedema, vascular injuries, vesiculobullous lesions, specific new onset of mucocutaneous presentations or aggravation of any especial previous dermatoses, nail changes, hair loss, non-specific

mucocutaneous problems, and vaccine-associated dermatoses were the 12 categories of our observations. Some of these presentations could be predictive of special outcomes and prognostic, which needed more evaluation. In the pandemic, if we counter with extensive mucocutaneous lesions with vascular components or vesiculobullous erosive lesions in association with any cutaneous rash, which could be an alarming sign of a probable life-threatening systemic event, we may need more exact evaluation and follow-up of patients.

Introduction

A few months after the COVID-19 outbreak, different COVID-19-associated mucocutaneous problems began to be reported from all over the world. These presentations have included morbilliform, varicelliform/herpetiform, urticarial, chilblains-like, livedoid, and acro-ischemic lesions, *etc*.[1,2]

This wide range of dermatologic manifestations can be classified into 3 main groups: i) primary, due to the direct effect of the virus or immunologic responses to it;[1] ii) secondary, related to drug reactions in COVID-19 patients or their hospitalization;[1,3] iii) adverse effects of health considerations, especially related to high usage of detergents and disinfectants like contact dermatitis.

On the other hand, the treatment of inflammatory diseases, including many dermatologic ones, is a challenging matter in the COVID-19 era, not only in the view of continuing or changing the immunosuppressive treatment but also in the view of the probable adverse effects of COVID-19-related therapies over the course of underlying dermatologic disorders.[4-6]

Among the most challenging encountered problems in critical COVID-19 patients, we have the adverse effects associated with drugs and therapy of patients; in the severe forms of dermatologic reactions, we usually need immunosuppressive drugs which may potentially aggravate COVID-19. On the other hand, the drugs leading to such reactions in these patients are not easily removable from the patient's medication list since they are usually necessary for the treatment of the disease, and inflammation as well as the control of any probable complication.[2,3,6]

Recognition and introduction of various types of mucocutaneous presentations of COVID-19, especially in admitted critical cases, is of great importance for dermatologists and all physicians involved in the management and treatment of COVID-19 cases in tertiary general hospitals.

To better understand and manage COVID-19-related mucocutaneous problems, it is necessary to report any experiences of dermatologic presentations during this pandemic in the original studies and then analyze them in systematic reviews and meta-analyses. For this purpose, in this original study, we reported COVID-19 patients admitted to two general COVID-19 centers that mainly covered the referral cases of the west of the capital city of Iran (Tehran) from April 2020 to June 2021. For these patients, dermatology counseling was requested due to mucocutaneous problems. Also, we tried to gather and report the main COVID-related dermatologic complaints of our outpatients in addition to some newly encountered vaccine-associated dermatologic reactions. It should be notified that although there were many dermatologic complaints in our COVID-19-affected outpatients such as herpes zoster, eczema, telogen effluvium, drug-induced acne, folliculitis, or exacerbation of previous dermatologic problems, we tried to report more specific mucocutaneous presentations of hospitalized COVID-19 patients in this study. The purpose of this study was to report the different types of mucocutaneous lesions of these patients in general, classify them, and propose treatment options for each class.

The main aim of this study was to recognize and introduce various types of mucocutaneous presentations of COVID-19, especially in admitted cases. In this way, physicians in all medical fields and specialties, who were involved and interacted with the treatment and management of COVID-19 patients, could faster and better diagnose the dermatologic signs, and if it were possible (especially in severe and potentially life-threatening ones), they would make the most appropriate and timely interventions in cooperation with the dermatologists. This may decrease the rate of COVID-19-associated critical complications and mortalities.

Materials and Methods

In this large case series study, we considered all dermatological consultations in COVID-19 patients admitted to 2 of the general tertiary referral COVID-19 centers, Rasool Akram Medical Complex and Firoozgar affiliated with Iran University of Medical Sciences. We visited them in the outpatient setting of the post-COVID period, from April 2020 to June 2021. All patients signed an informed consent form before participating in the study. The study was approved by the Ethics Committee of the Iran University of Medical Sciences. Also, we reported some newly encountered COVID-19 vaccine-associated dermatologic complications. The diagnosis of COVID-19 was based on the SARSCOV2-polymerase chain reaction and/or findings of the chest computed tomography scan indicative of COVID-19. We reviewed all mucocutaneous manifestations consulted or visited by dermatologists in this period and categorized them into the following groups:

i. Generalized papulopustular eruptions which may be drug-induced or not, like acute generalized exanthematous pustulosis (AGEP);
ii. Erythroderma due to a previous skin disease, especially psoriasis, which may be drug-induced or a post-COVID-19 reaction;
iii. Maculopapular lesions, especially in the pattern of viral exanthema and pityriasisrosea;
iv. Mucosal lesions, aphthous lesions, in the field of drug reactions or non-specific lesions;
v. Urticarial lesions and angioedema;
vi. Vascular injuries, skin manifestations with vascular components, such as vasculitis, vasculopathy, petechia, purpura, necrotic ulcers and disseminated intravascular coagulopathies (DIC);
vii. Vesiculobullous lesions divided into generalized [Stevens Johnson syndrome (SJS), toxic epidermal necrolysis (TEN), erythema multiforme (EM) major, bullous pemphigoid (BP)-like], and localized subgroups (herpetiform lesions);
viii. 8-specific new onset of mucocutaneous presentations like sclerodermoid changes or icter caused by COVID-19-induced hepatitis or aggravation of any previous dermatoses like psoriasis, pemphigus, vitiligo, eczema, and alopecia areata;
ix. Nail changes; onychomadesis and beau's lines;
x. Hair loss like telogen effluvium, alopecia;
xi. Non-specific mucocutaneous problems during hospitalization or the post-COVID period like fungal infection (candida, dermatophyte, mucormycosis, and aspergillosis), folliculitis, drug-induced or steroidal acne, herpes, zoster, etc;
xii. Vaccine-associated dermatoses, mostly pityriasis rosea, and urticaria.

Based on this classification, a case in each of these categories may have multifactorial or complex etiology and pathomechanism. For example, vasculopathy can be due to prophylactic anticoagulant therapy, COVID-19-induced coagulopathy, or vasculopathy. Another example is that of the exact pathomechanism of mucocutaneous problems that could be due to direct virus effects, host responses, and drug-related reactions or combinations which often could not be exactly identified. In this study, we proposed any probable underlying pathomechanisms for each group as far as possible in detail.

In this research, we mainly focused on individual cases of each category and types of presentation but due to certain circumstances of the pandemic, we could not follow the outcomes of these patients, especially consultant cases. Although in some categories, we had more than 10 patients, in the main text and each category, we presented only 4 pictures that were more typical, important, and evident. All pictures of all patients, based on the categories, have been attached as the main *Supplementary File* to this study for interested readers. The intellectual property rights of the authors of this article need to be protected by the publisher of this study.

Results

We reported more than hundred (121) COVID-19 patients with mucocutaneous presentations, classified them based on 12 predefined groups from April 2020 to June 2021, and took photographs of all of them, which have been presented in a comprehensive atlas at the end of this study as its main *Supplementary File*. The total number of visited patients was more than the mentioned number, especially in the outpatient dermatology clinics but we emphasized the specific cases with high-quality and appropriate pictures. A comprehensive clinical atlas has been attached to this article as a *Supplementary File* with 2 parts. In part 1, we presented a maximum of 4 pictures for each group at the beginning of our clinical atlas and the other remaining hundred figures related to these groups have been presented in part 2. In Table 1, you can see the details of these 12 groups.

Discussion

We visited many different dermatologic complaints in the outpatient clinics regarding COVID-19 and post-COVID-19 patients or patients suffering from a dermatologic disorder not directly related to COVID-19 itself, but due to special circumstances of the pandemic (such as wearing masks, frequent sweating, or increased sebum production due to masks, shields or special cloths, frequent use of soaps and alcoholic or non-alcoholic disinfectants, *etc*.) like the emergence of a dermatologic disease or aggravation of preexisting dermatoses such as alopecia areata, telogeneffluvium, melasma, post-inflammatory hyperpigmentation, eczema, contact dermatitis, exacerbation of seborrheic dermatitis, acne vulgaris, and acne rosacea, vitiligo, the incidence of drug-induced acne, infections due to the herpes virus family including herpes simplex or zona, *etc*. During this pandemic and in this study, we reported mostly important critical and non-critical dermatologic manifestations of hospitalized COVID-19 patients or in the next step, certain manifestations of outpatients with a history of COVID-19 infection in 11 groups, while in one other group, we reported our experiences of post-vaccine mucocutaneous presentations, and we discussed probable mechanisms of each group.

Drug-induced mucocutaneous manifestations

As we know, hydroxychloroquine is one of the drugs which may induce a drug reaction in the pattern of AGEP,[7] but it is also one of the first recommended drugs in the treatment of COVID-19 infection although, according to the last research, there is controversy about its positive effect on the prognosis and treatment of COVID-19 patients.[8] There have been many reports of hydroxychloroquine-induced AGEP in COVID-19 patients in the literature, similar to our patients in the papulopustular eruption group (group 1).[9] Another way in which hydroxychloroquine can be involved in the development of skin problems in COVID-19 patients is the onset of new lesions or exacerbation of previous lesions in patients with a history of psoriasis. Hydroxychloroquine, b-blockers and non-steroidal anti-inflammatory drugs are some of the suggested drugs that seem to aggravate psoriasis; there have been reports of these cases and progression of the psoriasis disease to erythroderma in COVID-19 patients under treatment of hydroxychloroquine.[10,11] In group 2 (erythrodermic eruptions), there were cases of erythroderma, following the use of hydroxychloroquine and b-blockers along with other factors such as abrupt discontinuation of psoriasis treatment due to COVID-19infection and fever.

Similar to other studies, our patients experienced more drug-induced dermatologic manifestations (other than AGEP) such as SJS, TEN, drug-induced erythroderma, and maculopapular rashes.[3,12]

About the management of these patients, in mild cases of drug reactions, discontinuation of the culprit drug as well as the administration of topical steroids and antihistamines may be helpful, but in moderate-severe cases, systemic immunosuppressants or immunomodulators such as steroids, cyclosporine, and intravenous immunoglobulin (IVIG) may be needed. These drugs can be logically involved in the progression of COVID-19, although the use of systemic steroids and IVIG has been reported in some studies to be beneficial in COVID-19 patients. The treatment and management of these patients definitely require a multidisciplinary approach.[13,14]

Among these drugs for controlling moderate-sever drug-induced mucocutaneous adverse effects, IVIG could be the best choice due to its mutual positive effect on the COVID-19 course and adverse drug eruptions but unfortunately, there has not been enough IVIG in all periods and peaks of the COVID-19 pandemic in Iran.

Infection-related (virus-induced, and virus-host-response-induced) mechanisms

As we know, one cause of the development or exacerbation of some dermatologic diseases such as psoriasis, urticaria, erythema multiforme, pityriasis rosea, vasculitis, vasculopathy, DIC, mucosal lesions (aphthous ulcers), nail changes (onychomadesis, and beau's lines) and hair changes (telogen effluvium, and alopecia areata) is viral infections (either as a direct effect of the virus or stimulation of the immune system).[6,15-19]

Among our patients, there were also reports of the mentioned diseases with direct and indirect mechanisms of infection. According to our observations, many of these patients did not require specific therapeutic interventions, but the lesions with components of vascular injuries and coagulopathy, especially on the systemic scale, were quite challenging therapeutically. It was evident that extensive vascular injuries could be correlated with higher rates of complications or mortalities and could even be prognostic; so, dermatologists and other physicians who deal with critically ill COVID-19 patients should have specific attention to

these alarming signs which could be lifesaving in certain cases.[20-24]

Although it was not possible for us to fully follow up with the patients, in general, among our patients, the ones with severe drug reactions and extensive vascular injuries had a poor general condition and a possible poor prognosis, almost all of them needed the intensive care unit services and we also observed a high mortality rate of them. In this study, we encountered some predictable and non-critical specific mucocutaneous lesions like urticarial and maculopapular exanthematous eruptions and pityriasis rosea. Also, we managed some critical dermatologic cases including SJS/TEN, AGEP, generalized BP-like, erythroderma, purpura fulminans, and extensive vascular-injury-induced lesions like ischemic-necrotic ones in the setting of DIC. In the case of non-critical presentations. We were usually successful in the management of patients, with antihistamines, topical care, and a little increase in the prescribed steroid dosage. The most therapeutic

Table 1. Details of the main 12 groups of mucocutaneous presentation related to COVID-19 and its vaccine.

Number and name of the group	Details (Figures in part 1 of *Supplementary File*)
i. Generalized papulopustular eruptions	In this group, there were 3 patients, 2 of whom had typical acute generalized exanthematous pustulosis patterns (Figure 1 a-c) and 1 had a history of hydroxychloroquine treatment (Figure 1 a,b). Another patient had a presentation of pustular psoriasis/AGEP patterns without a previous history of psoriasis (Figure 1d).
ii. Erythroderma	We had 4 patients. 2 had a previous history of psoriasis under treatment and were consulted due to erythrodermic reactions (Figure 2 a-c). The skin biopsy of these 2 patients was in favor of psoriasis. One was presented with pityriasisrubra pilaris(PRP)-like patterns that progressed to erythroderma within several weeks. In skin biopsy, hyperkeratosis with mild parakeratosis and the normal granular layer, mild vacuolar degeneration of the basal layer, mixed perivascular infiltration of lymphocytes, eosinophils, and neutrophils were reported and were in favor of drug-induced or post COVID-19 viral reactions. Another patient was also presented with a PRP-like pattern that progressed to erythroderma. The pictures of the patient with PRP-like pattern eruption have been shown in Figure 2d.
iii. Maculopapular lesions	In this group, we reported 16 patients, 9 of whom presented with pityriasis rosea patterns from 2 weeks to 2 months of COVID-19. The cutaneous picture of one of them has been shown in Figure 3a. The rest of them had localized or generalized exanthematous morbilliform rashes. One of these patients was affected by rhinocerebral mucormycosis during hospitalization, after surgery and antibiotic therapy while maculopapular rashes appeared on her skin (Figure 3b). Also, there were a child (Figure 3c) and a pregnant woman (Figure 3d) among our patients with generalized maculopapular skin lesions.
iv. Mucosal lesions	We reported 8 patients with oral or genital lesions. 2 had aphthous lesions; 3 had multiple erosions on the lips and tongue (Figure 4 a-c); and 2 had prominent lingual villi (strawberry tongue-like patterns) (Figure 4d) and one of them was with erosive lesions on his oral mucosa and glans of the penis.
v. Urticarial lesions and angioedema	We reported 16 COVID-19 patients with urticarial eruptions previous, during, and post the infection period. In 3 patients, urticaria was the pr senting sign of infection (Figure 5d) which had been started a few days before constitutional symptoms of COVID-19 and lasted for several months after the infection recovery. 4 patients had urticaria during the COVID-19 disease and 9 of them had this problem in the post-COVID 19 period (Figure 5 a-c).
vi. Vascular injuries	We reported 22 COVID-19 patients with different cutaneous manifestations of vascular injuries. 6 patients had acral vascular lesions such as severe acral cyanosis (Figure 6a), retiform purpura, ecchymotic lesions with a hemorrhagic bulla (Figure 6d), perniosis, chilblain-like lesions (Figure 6b), livedoid vasculopathy and petechia/purpura. 2 of these 6 patients with severe cyanosis and ecchymosis had been admitted to ICU. Other 15 patients had generalized cutaneous vascular injuries from mild petechiae and purpura (5 patients), to large ecchymotic-necrotic lesions with hemorrhagic bullae (10 patients) (Figure 6c), 6 of whom had ICU care. One patient, an old man, had an isolated necrotic lesion on the root of his nose.
vii. Vesiculobullous lesions	In this group, we reported 12 patients. One patient with bilateral herpetiform vesicles on the buttock and a punched-out appearance, 2 patients with large bulla on the base of erythematous-edematous plaques (BP-like) (Figure 7a,b), 3 patients with SJS/TEN/EM major patterns (Figure 7b), and 6 patients with typical SJS/TEN, 2 of whom had a positive drug history (antibiotics, Depakin) (Figure 7c). From the latter group, 2 patients were expired (Figure 7).
viii. Specific new onset of mucocutaneous presentations or aggravation of previous dermatoses	We reported 9 patients. One patient with a previous history of controlled pemphigus vulgaris developed hemorrhagic vesiculobullous lesions on the face (Figure 8a). One patient with stable vitiligo on his body deve oped new perioral lesions 6 weeks after COVID-19 infection (Figure 8b). 3 psoriasis patients had an exacerbated cutaneous and nail involvement after COVID-19 infection. One patient, an old man, had icter and generalized pruritus due to COVID-19-induced hepatitis. 2 patients with a history of xerosis and eczema had aggravation in skin manifestations as asteatotic eczema (Figure 8c) and severe hand eczema. One patient, a 50-year-old woman, had generalized progressive sclerosis of the skin and positive anti-nuclear antibody (ANA) and angiotensin-converting enzyme (ACE) levels, 3 months after COVID-19 infection without a previous history of the rheumatologic disease (Figure 8d).
ix. Nail changes	We reported 3 patients with beau's lines (Figure 9b), onychomadesis (figure 9a,d), and onycholysis (Figure 9c,d) from 3 to 8 months after COVID-19.
x. Hair loss	In this group, we had many cases in the outpatient clinics, with complaints of new onset of hair loss such as severe telogen effluvium, several months after COVID-19 infection; two of these patients have been shown in Figure 10 a,b. Also, some patients with a previous history of hair loss, for example, due to androgenetic alopecia or alopecia areata, had aggravation in the course of their disease.
xi. Non-specific mucocutaneous problems	We had 16 patients; 4 patients developed herpes zoster from 1 to 4 months after COVID-19 (Figure 11a,b); 4 patients were affected by superficial fungal infection (2 cases of candidiasis and 2 cases of dermatophytosis) (Figure 11c) during hospitalization; 7 patients had steroid-induced acne and folliculitis (Figure 11d); and one case of severe herpes simplex virus infection was observed.
xii.Vaccine-associated dermatoses (postCOVID-19 vaccine reactions)	In this group, we reported 10 patients including one patient with EM (Figure 12a), 3 patients with PR-like lesions (Figure 12b,c), 3 patients with complaints of pruritus, one patient with xerosis (Figure 12d) in his legs and some papular lesions in his figures and scrotum, 2 patients with generalized urticarial lesions and a patient with acral mild cyanosis and severe edema.

AGEP, acute generalized exanthematous pustulosis; BP, bullous pemphigoid; SJS, Stevens Johnson syndrome; TEN, toxic epidermal necrolysis; EM, erythema multiforme.

challenges were in critical dermatologic presentations which really needed holistic approaches, both effective and beneficial for the COVID-19 course, and in the dermatologic reactions; so choosing a logical management strategy in these cases might be aggravating for one of the concomitant COVID-19 infections or dermatologic eruptions.

In this study, we also observed some common and predictable dermatologic signs, but we encountered some interesting rare presentations. Although they could not be definitely interpreted to be resultant of a COVID-19 infection, the most responding cause was recent COVID-19 infections like livedoid vasculopathy (blanch atrophy), slerodermoid reactions, progression of vitiligo and pemphigus. What is important about this study is that the physicians of all fields, responsible for managing COVID-19 patients, especially those who are in the first-line system, should be aware of all probable critical dermatologic complications to choose better management strategies and proper treatments for patients since, based on our opinion in some cases, early diagnosis could be life-saving. Also, dermatologists could be more familiar with these types of mucocutaneous presentations for better counseling to critical COVID-19 patients or early diagnosis of suspected cases, which help adopt an early treatment and prevent the disease from spreading.

Since a hot topic of today has been the probable critical and non-critical adverse effects of the COVID-19 vaccine (an adverse vaccine),[25-29] we tried to present our encountered vaccine-related mucocutaneous dermatoses, all of which were non-critical, mainly urticarial and Pityriasis rosea. Although some were rare, critical presentations were also expectable and needed to be reported and released over time.

The authors of this study have been highly focusing on major dermatologic concerns in this pandemic area, and now they present the most important and biggest original COVID-19 study with a unique dermatologic atlas of their patients.[2,3,6,20,22-24,30-36]

Conclusions

In this study, we reported 121 hospitalized and outpatient cases with full images of their mucocutaneous dermatological manifestations, also newly emerged vaccine-associated dermatoses in 12 categories. These categories were:

i. Generalized papulopustular eruptions (3 patients);
ii. Erythroderma (4 patients);
iii. Maculopapular lesions (16 patients);
iv. Mucosal lesions (8 patients);
v. Urticarial lesions and angioedema (16 patients);
vi. Vascular injuries (22 patients);
vii. Vesiculobullous lesions (12 patients);
viii. Specific new onset of mucocutaneous presentations or aggravation of any previous dermatoses (9 patients):
ix. Nail changes(3 patients);
x. Hair loss (2 patients);
xi. Non-specific mucocutaneous problems (16 patients);
xii. Vaccine-associated dermatoses (10 patients).

In categories viii-xi, the actual number of visited patients was higher than the mentioned numbers. We just mentioned the patients of whom we had photographs. Some of these presentations were drug-induced, virus-induced, or virus-host-interaction-induced lesions. Some of these presentations could be predictive of special outcomes and prognostic, which needed more evaluation. In the pandemic, if we countered the extensive mucocutaneous lesions with vascular components or vesiculobullous erosive lesions in association with any cutaneous rash, which could be an alarming sign of a probable life-threatening systemic event, we would need to approach them as soon as possible like the request of lab data of sepsis, hypercoagulopathy states, any end-organ failure or systemic complications, considering any suspected drug eruption. It has been highly expected to encounter mucocutaneous eruptions after COVID-19 vaccination, which may be more reported over time, although most of them may be non-critical and self-limited.

Limitations and recommendations

In this study, we mainly focused on individual cases of each category and types of presentation but due to certain circumstances of the pandemic, we could not follow the outcomes of these patients, especially consultant cases. We suggest designing original systematic reviews and meta-analyses to evaluate follow-up and outcomes of patients with dermatologic signs of each category to reach a better judgment on the prognostic value of these signs. It was not possible to add all patients' pictures to the main document due to the predetermined limitations of figure numbers in original studies. Also, since most of the presented cases of this study were admitted COVID-19 patients in wards or intensive care units (ICUs), histopathological evaluation of their dermatologic signs was not possible. So, these data may be highly informative or prognostic and we hope to approach this concern in future studies.[21-23] The purpose of this study was to introduce all possible dermatologic manifestations of COVID-19 in hospitalized patients to the practitioners involved in their treatment, but it requires more studies with larger sample sizes and follow-up to comment on the predictive and diagnostic role of these manifestations. As previously mentioned, because the patients were from different medical centers and hospitals, we could not follow up on all of them. Consideration of the dermatologic lesions in COVID-19 patients, especially in ones with poor general conditions, and precise follow-up may be useful to improve the prognosis and even the therapeutic approaches to other COVID-19 patients with similar conditions, such as timely administration of anticoagulants or immunomodulators.

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Online supplementary material:
Part 1: four pictures for each individual category (12 groups).
Part 2: More pictures of all categories