Introduction

The coronaviruses (CoVs) are members of the order Nidovirales, family Coronaviridae, and genus Coronavirus. The official name of this virus is SARS-CoV-2. Seven CoV species are known to infect people. Only MERS-CoV and SARS-CoV have the capacity to lead to serious human illness.

The remaining are linked to minor respiratory illnesses like the common cold.

The virus also seems to involve the musculoskeletal system. Though these are believed to be infrequent presentations of infection with the SARS-CoV-2 virus.

The illness also affects people globally on a moral or psychological, legal, and political level. These obstacles have a significant impact on the nation’s economic progress.

Case Presentation

Presentation and examination

A 47-year-old male patient had a history of positive reverse transcription–polymerase chain reaction (RT-PCR) test for SARS-CoV-2 infection three months before, for which he was hospitalized and consequently underwent treatment in the form of antibiotics, prophylactic thrombolytics, and supportive care therapy. At the time of presentation, he came to our tertiary care center in central India with complaints of pain and swelling over the right lower limb for 20 days. The pain was insidious in onset, gradual in progression, and was initially present over the anterior aspect of the right lower limb at the calf region and later progressed to the anterior compartment. The pain aggravated during physical activities and relieved on rest. The swelling was present over the right lower limb, which was smooth, diffuse in nature, and associated.

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Laboratory investigations

The values of the complete blood count were as follows: Hemoglobin 14.5g/dL, Hematocrit 44%, RBC count 4.9x10^12/microl, mean corpuscular volume (MCV) 89fl, mean corpuscular hemoglobin concentration (MCHC) 33, red blood cell distribution width (RDW) 12%, platelet count 230x10^9/microl. The WBC count was found to be raised. Biochemical tests for detection of inflammatory markers were performed, which revealed C-reactive protein (CRP) 30mg/L, erythrocyte sedimentation rate (ESR) 40mm/hr, lactate dehydrogenase (LDH) 748 IU/L and creatine kinase (CK) 644 IU/L. A significantly high value of CRP, ESR, lactate dehydrogenase (LDH), and CK was noted. Differential diagnoses of a nervous system disease such as encephalitis, myelitis, or Guillain-Barré syndrome were ruled out due to normal neurological and muscle strength testing were within normal limits.

Imaging findings

It made ultrasonography examination of the swelling showed increased diffuse homogenous echogenicity in the subcutaneous, soft tissue, and surrounding muscles in the posterior compartment of the right lower limb. The extensor digitorum longus and peroneus longus were shown to exhibit enhanced echogenicity that was diffusely distributed along the muscles in the anterior compartment and lateral compartment, respectively.

The patient was therefore started to undergo magnetic resonance imaging (MRI) for further evaluation. In the MRI of the right lower limb, there was evidence of extensive T2/STIR hyperintensities in muscles of the anterior compartment (extensor digitorum longus), lateral (peroneus longus), superficial posterior compartment (plantaris, gastrocnemius, and soleus) and intermuscular facial planes, predominantly in the anterior compartment (extensor digitorum longus).

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FIGURE 1: Axial section STIR sequence of right lower limb.
Axial section STIR sequence of right lower limb showing extensive intramuscular hyperintensities in the anterior compartment (extensor digitorum longus), lateral (peroneus longus), and superficial posterior compartment (plantaris, gastrocnemius, and soleus) and intermuscular fascial planes, predominantly in the proximal part. There are no evidence of necrotic changes.

FIGURE 2: Axial section T2-weighted sequence of the right lower limb.
Axial section T2-weighted sequence of right lower limb showing extensive intramuscular hyperintensities in the anterior compartment (extensor digitorum longus), lateral (peroneus longus), and superficial posterior compartment (plantaris, gastrocnemius, and soleus) and intermuscular fascial planes, predominantly in the proximal part. There are no evidence of necrotic changes.
FIGURE 3: Coronal section STIR sequence of right lower limb

Coronal section STIR sequence of right lower limb showing extensive intramuscular hyperintensities in the anterior compartment (extensor digitorum longus), lateral (peroneus longus), and superficial posterior compartment (plantaris, gastrocnemius, and soleus) and intermuscular fascial planes, predominantly in the proximal part. There are no necrotic changes.
FIGURE 4: Coronal section T2-weighted sequence of the right lower limb.
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Treatment and follow-up
A course of the nonsteroidal anti-inflammatory drug (NSAID), namely, Indomethacin 75mg OD, and immunomodulators such as glucocorticoids, namely, Prednisolone 50mg OD were advised to the patient for three weeks with tapering of Prednisolone dosage after two weeks. A month after receiving the therapy, the patient underwent a follow-up examination. The patient’s symptoms had entirely subsided without a trace of the presenting complaints. The subsequent biochemical tests for inflammatory markers such as ESR, CK, and LDH readings had all returned to baseline.

Discussion
The SARS-CoV-2 coronavirus was formally declared a pandemic on March 11, 2020 [2,3]. There have been over 21 million cases of COVID-19 as of August 2020, reported worldwide, with over 800,000 COVID-19-associated deaths [4]. The possibility of developing a severe form of the illness is more so in older age groups and patients with comorbidities such as cardiovascular disease, diabetes mellitus, and obesity. Corticosteroids, mechanical ventilation, thromboembolic prophylaxis, and oxygen therapy are potential therapeutic options for COVID-19 patients who are experiencing acute symptoms [5]. Treatment guidelines, prevention measures, and presentations of COVID-19 are currently being updated. The SARS-CoV-2 is a single-stranded (positive sense) RNA virus that is coupled with a nucleoprotein inside a capsid made of matrix protein in spherical or pleomorphic enclosed particles. In addition to the gastrointestinal system, urinary system (kidney and bladder), the pancreas, spleen, heart, and blood vessels, the Angiotensin-converting enzyme 2 (ACE2) receptor is highly expressed in lung epithelial cells [3,5]. Additionally, the central and peripheral neural systems, as well as diaphragm muscle, contain ACE2 receptors. [6] Angiotensin-converting enzyme 2 receptors are found in human cells and are recognized by this RNA virus. Viral release by cell apoptosis occurs after replication of the virus within human host cells [6]. Additionally, coronavirus induces an inflammatory response (including immunological responses, which are natural innate, and adaptive), which may lead to an overproduction of cytokines and eventually multi-organ destruction [7,8]. A patient affected with SARS-CoV-2 may present without any debilitating symptoms or with mild to moderate upper respiratory tract infection (URTI) or with acute respiratory distress syndrome (ARDS). Initially, it was primarily known to affect the respiratory system. It is now recognized that SARS-CoV-2 infection can cause a wide range of extrapulmonary signs. Gastrintestinal symptoms, dysfunction of the heart, kidneys, and liver, acute coronary syndrome, dermatologic abnormalities, and neuromuscular involvement are the extrapulmonary manifestations noted. Although myalgia is a prevalent clinical symptom in SARS-CoV-2 virus–affected individuals, early in the pandemic, additional musculoskeletal signs of COVID-19 were seldom reported [3-5]. Nonetheless, there have been more reports of rheumatologic problems and neuromuscular symptoms linked to the COVID-19 virus, the associated therapy, and course in the hospital as the number of patients and survivors increased globally [6]. COVID-19–associated musculoskeletal symptoms need to be carefully evaluated and managed, in order to avoid further complications such as rhabdomyolysis, which eventually leads to damage to vital organs such as kidneys. Imaging techniques such as ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI) can help in the diagnosis and evaluation of COVID-19–associated musculoskeletal symptoms and extrapulmonary complications. In this article, we discuss the imaging characteristics and the mechanisms with which SARS-CoV-2 affects the musculoskeletal system. In particular, we review the various pathologies affecting the muscle. In extensive cohort studies, myalgia, which is characterized as muscle aches and pains, has been repeatedly observed in SARS-CoV-2 infection with a prevalence ranging from 11% to 58% [6]. Myalgia and rhabdomyolysis have been mentioned in several case reports as occurring in SARS-CoV-2 infection. It can occur as both a late consequence of the infection or a presenting symptom. There have been...
a few isolated reports of COVID-19-affected patients with exacerbating autoimmune myositis. The mechanisms behind the involvement of the muscles in COVID-19 remain unclear. It has been shown that SARS-CoV-2 can propagate hemorrhage and directly invade skeletal muscle by binding to the ACE2 receptor [6,7]. A distinct and more widely recognized notion of SARS-CoV-2 muscle involvement is immunological-mediated mechanisms, which are assumed to be an inflammatory response with immune cell activation and massive release of cytokines. Cytokines released from the muscle due to toxicity, injury resulting from the similarity between human muscle cells and viral antigens, and deposition of immune complexes are some of the hypothesized mechanisms of immune-mediated damage to the muscle [7].

Myositis is a general term for muscle inflammation and has been linked to viral illnesses such as Hepatitis, HIV, and influenza A/B, in addition to coronavirus. A side effect of myositis is myonecrosis and myoglobinemia which is due to muscle infection and released myoglobin levels in the blood due to diaphragm dysfunction, respectively. Diaphragm dysfunction is a potentially fatal illness that can result in intracranial congestion, compartment syndrome, and acute renal failure [4]. Myalgia and/or weakness and increased CRP levels have both been noted in individuals affected by COVID-19, which are typical clinical signs of myositis/thallomyositis [9,8]. Other illnesses causing muscle weakness or muscular sequelae include neurological disorders like muscular dystrophies, multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS), autoimmune diseases such as Graves’ disease, myasthenia gravis, thyroid conditions, and electrolyte imbalances that can be ruled out [6].

To establish a myopathic process and rule out akinetic or motor neuron illnesses, electromyographic investigations like electromyography (EMG) and nerve conduction study (NCS) are valuable diagnostic tools [7].

The preferred imaging technique in MRI is ideally using a 1.5-T or 3.0-T magnet and including fluid-sensitive multiplanar, anatomic sequences. Muscle edema is detected as a rise in signal intensity on short tau inversion recovery sequences (STIR) or T2-weighted sequence, which is suggestive of findings of myositis [10]. Hyperintense hypertrophied muscle signal enhancement, heterogeneous hyperintense signal, and rim enhancement are common findings [11]. Region of necrosis or the loss of typical muscle architecture may be visible in severe illness. The “stippled sign,” which consists of a region of non-enhancing muscle tissue with a surrounding rim of enhancement that contains enhancing foci within the muscle is a distinctive feature of myonecrosis [6]. On gradient echo sequences, intramuscular hemorrhage can be seen as a T1 hyperintense signal or a blooming artifact [9].

A commonly accepted condition affecting the muscular system in SARS-CoV-2-affected individuals needing ICU care is critical illness myopathy. It has been seen in association with corticosteroid use in patients on ongoing treatment for COVID-19. Corticosteroidal therapy is still the key treatment and recommendation for specific critically ill patients because of its strong anti-inflammatory and anti-fibrotic effects [12]. Thus, it is one of the differential diagnoses for muscle syndrome noted on MRI evaluation of SARS-CoV-2-affected individuals who are hospitalized. Symmetrical or widespread swelling or sudden fluid of quadriceps is one of the clinical manifestations of critical illness myopathy, which is a primary myopathy [13]. Critical illness myopathy has non-specific imaging features of widespread muscular atrophy and edema. In contrast to the thallomyositis/myonecrosis associated with COVID-19, there are no signs of necrosis in critical illness myopathy. In one research of critically sick COVID-19 patients done by Cabanes Martinez et al., the degree of spontaneous activity on electromyographic examinations was shown to be notably severe [14]. Patients with COVID-19 may develop dysfunction of the most principal muscles of the respiratory and the diaphragm. Dysfunction may occur as a result of phrenic nerve injury, potentially as a result of the implantation of chest support devices or critical illness myopathy and maybe ventilator-induced diaphragm dysfunction. The SARS-CoV-2 virus could theoretically cause direct neuromuscular involvement, which could result in diaphragm dysfunction. A recent autopsy investigation done by Shi et al. discovered the expression of Angiotensin-converting enzyme 2 receptor in the SARS-CoV-2 virus mRNA and in the human diaphragm in a subgroup of COVID-19 patients who had diaphragm dysfunction [15]. Diaphragm dysfunction might cause respiratory problems and/or make it difficult to stop using ventilatory support in patients [12-14]. A rapid evaluation of diaphragm excursion is of utmost importance and is provided by the fluoroscopy sniff test, which is rapid and provided in real-time. Additional information is provided by ultrasound which demonstrates diaphragm muscle atrophy, examination of excursion with M-mode, and the muscle thickening ratio with respiration. In the neck region, high-resolution ultrasound can also assess the phrenic nerve, which may help distinguish between neuropathic and myopathic causes of diaphragm failure. In COVID-19 patients with prolonged illness, long term muscular sequelae like sarcopenia and cachexia are noted and have been well documented [16]. Muscle loss, also known as sarcopenia or myopenia, is mostly brought on by aging; however, inactivity and poor diet can also be contributing causes. Muscle wasting is caused by a persistent condition known as cachexia. For inflammation and muscle size or MRI imaging signs of muscular atrophy, which are seen in sarcopenia and cachexia [16].

For the treatment of myositis, a variety of immunosuppressive and immunomodulatory therapeutic drugs are currently available. Glucocorticoids and immunosuppressants continue to be the first-line treatments; early start and enough dosage can result in disease stabilization, strength recovery, and a reduction in inflammation. However, it is important not to underdose the negative effects of immunosuppressive therapy. Early addition or escalation of therapy should be prompted by refractory cases and extra muscular symptoms, such as intermittent lung disease, heart involvement, etc. Treatment of difficult cases is dealt with by innovative treatment strategies that target particular immune pathways that show great promise. It should accurately anticipate the response to a particular treatment, it is also imperative to conduct an additional study into the pathophysiology of myositis. Together, these initiatives may, perhaps, lead to future advancements in myositis therapy [13].

Conclusions

COVID-19 and its predictable manifestations are generally recognized and studied extensively. The unusual imaging manifestations of COVID-19. Part 1. Viral effects

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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