Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Heterotopic ossification and COVID 19: Imaging analysis of ten consecutive cases

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ABSTRACT

Purpose: Heterotopic ossification (HO) is defined by the formation of mature lamellar bone in periarticular soft tissue due to prolonged immobility. This study aimed to explore the imaging features of HOs in immobilized COVID-19 patients compared to other causes previously described in the literature.

Method: This retrospective single centre study included patients with severe COVID-19 hospitalized in intensive care unit (ICU) with mechanical ventilation and affected by HOs between March 2020 and December 2021. Two radiologists reviewed imaging features of biphasic CT-scans using a standardized template including morphological findings and anatomical relationship of the HO with the joint, vessels and nerves.

Results: 10 COVID-19 patients with 19 analyzed HOs following ICU hospitalization were including. Biphasic CT imaging characteristics were analyzed. The hips were the most commonly affected joint (n = 14/19; 74%). The distribution was mainly posterior (n = 7/19; 38%). HOs were located away from main arteries. No case of severe demineralization was observed. Capsular disruption was observed for three HOs (n = 3/19; 16%). One patient presented concomitant venous thrombosis ipsilateral to the HO. CT-scan demonstrated neural involvement of the sciatic nerve in 3 patients with HO (n = 3/19; 16%).

Conclusion: Severe COVID-19 patients with a biphasic CT imaging presented HO mainly located around the hips, with rare vessel and nerve invasion and no severe demineralization. Some features such as a lower level of local invasion differ from HOs related to other disorders as described in the literature whereas morphological aspects are similar.

Dear Editor,

In COVID-19 patients hospitalized in intensive care unit (ICU), and requiring mechanical ventilation, heterotopic ossifications (HO) were one of the complications observed, affecting more particularly the pelvic girdle [1–3]. Most COVID-19 studies focused on pulmonary disorder and acute condition but long-term functional prognosis is an increasing problematic.

Heterotopic ossification (HO) defined by the formation of mature lamellar bone in periarticular soft tissue can lead to different symptoms (disability, pain, stiffness, fever, nerve compression) [4,5]. Previous studies reported a radiological description of HO in other causes of prolonged immobilization using biphasic computed tomography (biphasic CT) [6,7]. However, to date, there is no study evaluating imaging features of COVID 19-related HO, nor providing a radiological assessment of HO using biphasic CT in COVID-19 patients hospitalized in ICU.

We aimed to explore imaging features of HOs in patients with COVID-19.

This retrospective, monocentric study was conducted between March 2020 and December 2021, in a tertiary center of rehabilitation medicine. Ten patients with severe COVID-19, hospitalized in ICU, were included. Nineteen HO were analyzed on biphasic CT. All these patients had an indication for partial or total surgical excision, requiring a pre-operative assessment by computed tomography scan with contrast injection.

Two radiologists, with 6 and 4 years of experience in musculoskeletal imaging, performed a consensual review of the radiological data using a template to ensure standardized reporting.

For every analyzed HO, the following elements were reported: joints involved, laterality, location of the HO, bone mineralization,

Abbreviations: CERIM, Medical Imaging Research Ethics Board; CT, Computed tomography; OH, Heterotopic ossification; HU, Hounfield Unit; ICU, Intensive care unit; IRB, Institutional Review Board.

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Table 1
Radiological characteristics of HO on biphasic CT.

	Number (%)
HO site	
Hip	14 (74)
Knee	5 (26)
Laterality*	
Unilateral	3 (30)
Bilateral	7 (70)
HO distribution	
Anterior	6 (31)
Posterior	7 (38)
Mixed	6 (31)
Bone mineralization score	
M1	1 (5)
M2	17 (80)
M3	1 (5)
M4	0 (0)
Relation with capsule	
No contact	1 (5)
Contact	15 (79)
Capsule disruption	3 (16)
Joint narrowing	
Normal	17 (80)
Narrowed	2 (10)
Ankylosis	0 (0)
Relation with arteries	
Non relationship	16 (84)
Displacement	3 (16)
Gutter	0 (0)
Tunnel	0 (0)
Relation with veins	
Non relationship	17 (80)
Displacement	1 (5)
Gutter	0 (0)
Tunnel	1 (5)
Relation with nerves	
Non relationship	10 (54)
Displacement	6 (31)
Gutter	2 (10)
Tunnel	1 (5)

* There were 10 patients for laterality and 19 analyzed HO for other items.

relationship to the capsule, joint space assessment, relationship to blood vessels and nerves. Capsular disruption was subjectively determined on the CT scan with at least a focal absence of visualization of the capsule due to the extension of HO. The bone density at the femoral head on CT was compared with that of the ilium immediately above the acetabulum [6] and graded as: no difference (M1), focal areas of demineralization (M2), demineralization of a larger confluent area, with preservation of central trabecular bone (M3), complete demineralization (M4) (Table 1).

Vascular or neural invasion were also graded and categorized among the following: small displacement, gutter if the contact was inferior to 180° of the circumference, and tunnel in case of complete embedment of the vessel. Cases of thromboembolic disease were also reported (Table 1).

Biphasic CT was performed for preoperative assessment [6–8], with a 16-section scanner and a collimation of 128 × 0.625 mm. The acquisition was triggered 135 s after the start of the injection, with the following parameters: voltage at 120 kV, amperage at 300 mAs/slice, and rotation time at 0.5 s/rotation. Multiplanar reconstructions were performed as well as 3D volume rendering with color-coding according to tissue densities (Fig. 1 A).

HOs were more frequent around the hip, had a posterior location, a relative preserved mineralization, and cases of capsular or vasculo-nervous invasion were uncommon as shown in Table 1.

We found a similar distribution in our study and the literature, with the hip as the most frequently affected joint. One noticeable element is that we found in our study six patients with anterior muscle involvement (n = 6/19; 31%) versus 64 patients (n = 64/132; 48%) in the literature [7].

We observed a slight increase in nerve displacement with six HOs (n = 6/19; 31%) in our study versus 12 patients (n = 12/132; 14%) in the literature. We observed two gutters (n = 2/12; 10%) as shown in Fig. 1.B and one tunnel (n = 1/19; 5%) versus 15 gutters (n = 15/132; 17%) and three tunnels (n = 3/132; 3%) respectively in the literature [7].

We observed less vascular invasion than in prior analyses, with vascular displacement observed in 17 patients (n = 17/132; 13%) of cases in the literature [7] versus three patients (n = 3/19; 16%) and one patient (n = 1/19; 5%) for arterial and venous displacement respectively in our work. Fig. 1.C shown a single case of thrombosis.

The rate of capsular disruption was equivalent to prior studies. However, less severe joint shrinkage was observed in our study. Indeed, joint shrinkage was reported in two patients (n = 2/19; 10%) versus 33 patients (n = 33/132; 25%) in the literature (Fig. 1 D). Furthermore, there were no cases of ankylosis versus 17 cases of ankylosis (n = 17/132; 13%) in previous study [7].

Bone demineralization also appeared less severe in our population. One patient had normal mineralization (M1) (n = 1/19; 5%) and 17 patients had mild demineralization (M2) (n = 17/19; 80%). Only one patient (n = 1/19; 5%) had significant demineralization (M3) versus (n = 18/132; 14%) in the literature [7]. There were no cases of severe demineralization (M4) versus (n = 9/132; 7%) in the literature [7].

A possible explanation for these findings could be the shorter duration of evolution of HO in patients with COVID-19.

In conclusion, COVID 19-related HOs exhibited a few specific imaging features, especially less severe damage to the vascular and neural structures, less bone severe demineralization and less joint shrinkage. This is most likely due to a shorter time course of the pathology, compared to other causes of HO. On the other hand, there was no predominance of anterior muscle involvement, as would have been expected due to prone position of patients hospitalized in ICU for COVID-19 infection.

Compliance with ethical standards

The study was approved by CERIM (Medical Imaging Research Ethics Board) ethics Committee (IRB: CRM-2201-221).

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Declaration of Competing Interest

The authors declare that they have no known competing financial

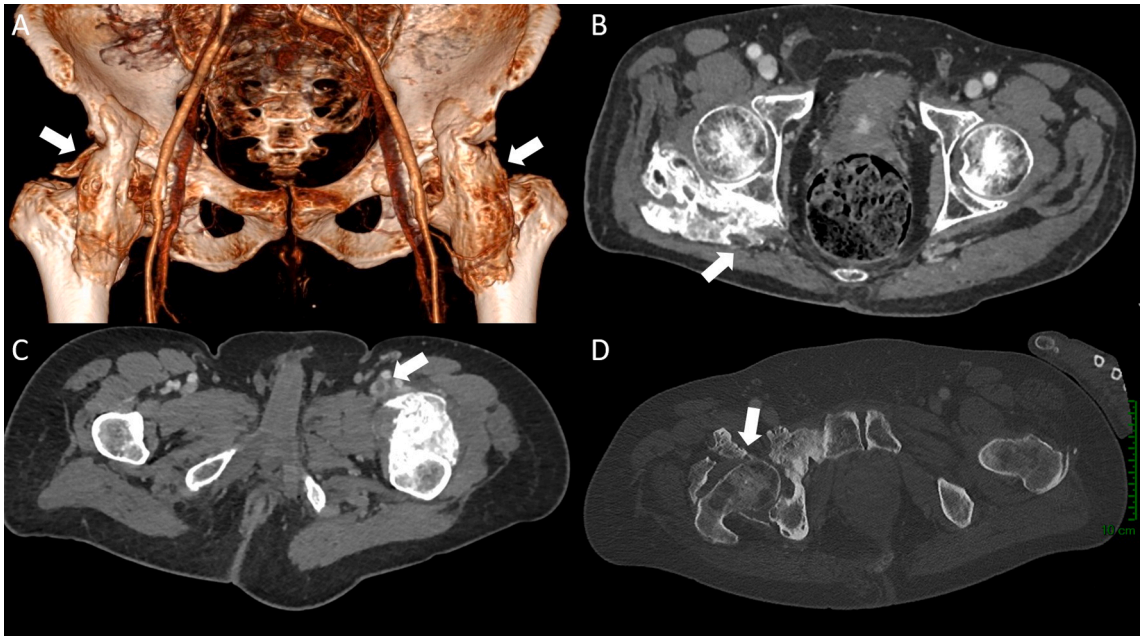

Fig. 1. Cases of four different patients with five analyzed HO on biphasic CT. A: Enhanced-CT in volume rendering illustrating a case of a bilateral anterior hip HO (white arrows). This modality allows a precise analysis of the vessels with color-coding according to tissue densities, making bone appear in white, veins in red and arteries in orange [339 (±32) HU for bones, 253 (±13) HU for arteries and 206 (±21) HU for veins]. Arteries are distinguishable of veins because of the difference of contrast media concentration; B: Axial biphasic contrast enhanced CT images of a patient with HO of the right hip with an embedment of the sciatic nerve (white arrow). C: Axial biphasic contrast enhanced CT images of a patient with HO of the left hip causing superficial femoral vein displacement. Endoluminal defect inside the femoral vein indicating a thrombosis (white arrow); D: Axial biphasic CT-scan on bone window CT of a patient with HO of the right hip with anterior capsular disruption (white arrow); HU: Hounsfield Unit.

interests or personal relationships that could have appeared to influence the work reported in this paper.

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Sarah Mezghani[a,*], Marjorie Salga[b,c], Mickael Tordjman[a], Raphaël Amar[d], Robert-Yves Carlier[a,d,e], Lea Chiche[a]

[a] *APHP - GHU Paris Saclay, DMU Smart Imaging, Department of Radiology, Raymond Poincaré Teaching Hospital, Garches, France*

[b] *Department of Physical Medicine and Rehabilitation, Raymond Poincaré Teaching Hospital, France*

[c] *CIC 1429, Garches, France*

[d] *APHP - GHU Paris Saclay, DMU Smart Imaging, Department of Radiology, Ambroise Paré Teaching Hospital, Boulogne, France*

[e] *UMR 1179 End-icap Université Versailles Saint-Quentin en Yveline/Paris-Saclay, France*

[*] Corresponding author at: Department of Radiology, Raymond Poincaré Teaching Hospital, 104 boulevard Raymond Poincaré, 92380 Garches, France.

E-mail addresses: sarah.mezghani@aphp.fr (S. Mezghani), marjorie.salga@aphp.fr (M. Salga), mickael.tordjman@aphp.fr (M. Tordjman), raphael.amar@aphp.fr (R. Amar), robert.carlier@aphp.fr (R.-Y. Carlier), lea.chiche@aphp.fr (L. Chiche).