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CLINICAL APPLICATION OF COVID-19 REPORTING AND DATA SYSTEM IN COMPUTED TOMOGRAPHY OF BILATERAL PNEUMONIA DIAGNOSTIC

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Keywords: COVID-19, Pneumonia, CT scan, CO-RADS, SARS-Cov-2.

Summary

Background: the 2019 coronavirus disease pandemic (COVID-19) has spread at an astonishing speed across the world, causing major morbidity and mortality. Computed tomography (CT) examination plays an important role in crisis areas in the diagnosis of COVID-19. COVID-19 Reporting and Data System (CO-RADS) has a five-point scale of suspicion for COVID-19 pneumonia in chest CT picture which standardizes the evaluation scheme and simplifies reporting.

Aim: to summarise and present the role of COVID-19 Reporting and Data System in computed tomography of bilateral pneumonia diagnostic.

Materials and methods: recently published studies were reviewed to evaluate COVID-19 Reporting and Data System scale as effective tool to detect COVID-19 pneumonia on chest CT scans. Databases from the subscription list of Lithuanian University of Health Sciences were selected: Medline (PubMed), SpringerLink and ScienceDirect.

Results: chest CT features, as bilateral involvement, subpleural or peripherally distributed GGO, consolidation, reticulation, crazy paving pattern, air bronchogram signs, intralobular septal thickening, pulmonary vascular enlargement, are considered to be characteristic manifestations of COVID-19 infection. Studies show that Dutch Radiological Society presented CO-RADS scale sensitivity and specificity may vary from 61-88% and 66,4-98%, respectively.

Conclusion: chest CT scan has a high sensitivity for COVID-19 diagnosis and could reduce false negative results obtained from RT-PCR tests. Furthermore, a standardized reporting system could increase clarification, minimize reporting variability and help radiologists recognize the results they observe, especially, for less experienced specialists.

Introduction

The coronavirus disease pandemic of 2019 (COVID-19) has spread across the globe at an unprecedented pace, causing substantial morbidity and mortality. Immediate triage of COVID-19 infection suspected patients using chest computer tomography (CT) may be helpful when results from definitive viral testing are pending [1]. The Dutch Radiological Society (Nederlandse Vereniging voor Radiologie) launched a COVID-19 network in early March 2020 to facilitate development and distribution of COVID-19-related knowledge and tools around the nation. Standardized CT scoring systems, such as the COVID-19 Reporting and Data System (CO-RADS), have been proposed to improve communication between radiologists and other health care providers trough converting radiologic findings into standardized scores. CO-RADS rates the likelihood of COVID-19 pulmonary involvement on a scale of 1 to 5 (very low to very high). A technically insufficient examination (CO-RADS category 0) and RT-PCR–proven severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection at the time of examination (CO-RADS category 6) are two additional categories [2]. Futhermore, this scoring system also report the extent of parenchymal involvement by assigning a CT severity score to patients highly suspected of having COVID-19 [1]. COVID-19 has CT findings that partly overlap with those of other diseases, mostly viral infections, but also has distinct characteristics that are less common in other settings [2]. Such standardized scoring systems allow for quick and consistent clinical decision-making, which is particularly important during these difficult times. CO-RADS is a CT-based

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method that is used in COVID-19 to determine the suspicion of pulmonary involvement [1]. The actual interpretation of whether a patient has COVID-19 needs to include information, such as laboratory test results, clinical observations, and the type and duration of symptoms. Positive RT-PCR results are still the gold standard for diagnosing COVID-19 at the moment [2].

This article aims to summarise and present the role of COVID-19 Reporting and Data System in computed tomography of bilateral pneumonia diagnostic.

Materials and methods

Recently published studies were reviewed to evaluate COVID-19 Reporting and Data System scale as an effective tool to detect COVID-19 pneumonia on chest CT scans. Databases from the subscription list of Lithuanian University of Health Sciences were selected: Medline (PubMed), SpringerLink and ScienceDirect.

Results

Chest CT has become a significant imaging modality in the assessment and monitoring of COVID-19 pneumonia patients [3], with sensitivity of 97 % [4], indicated the need for a standardized assessment model that would ease the analysis and reporting of imaging examinations, serve as a basis for reliable referral generation, and increase patient care quality [5]. Towards this aim, the Dutch Radiological Society introduced CO-RADS demonstrating a sufficient diagnostic accuracy for predicting COVID-19 pulmonary presence [2]. CO-RADS is classified into 6 categories and are the fallowing:

CO-RADS 0 defines technically insufficient scans, such as those with respiratory motion interference or scans that are invalid with a very poor quality [2].

CO-RADS 1 represents a very low presumption of COVID-19, includes findings such as a normal scan or ones that reveal apparent evidence of non-infectious pathology that encompasses a variety of other findings, including, emphysema, lung tumors, fibrosis, or perifissural nodules [2]. This correlates with the Radiological Society of North America (RSNA) consensus statement on reporting chest CT findings for Negative Pneumonia category [6] that indicates no features in the parenchyma of the lungs that may be caused by infection, in particular, no peripheral or nodular ground-glass opacities (GGO) and consolidation could be seen [7].

CO-RADS 2 shows a low level of suspicion of pulmonary damage caused by COVID-19 infection, though, it has imaging results that are characteristic of infective etiology but not COVID-19-compatible. These findings may cover bronchitis, infectious bronchiolitis, bronchopneumonia, lobar pneumonia, and pulmonary abscess that could be seen in a chest CT as a tree-in-bud sign, a centrilobular nodular pattern, lobar or segmental consolidation, and lung cavitation [2]. Atypical Appearance category of RSNA consensus statement has CT findings [3] that are close to CO-RADS 2, however, it excludes smooth interlobular septal thickening with pleural effusion and appoints as CO-RADS 1 if it manifesting as interstitial pulmonary edema or CO-RADS 3 if ground-glass opacities are noticed, giving it a better interpretation of pulmonary damage assessment.

CO-RADS 3 applies to CT findings that are equivocal with COVID-19 pulmonary involvement but can also be found in other forms of viral pneumonia or non-infectious causes. Findings include perihilar ground-glass, homogenous extensive ground-glass with or without sparing of some secondary pulmonary lobules, or ground-glass together with smooth interlobular septal thickening with or without pleural effusion if there are no other common CT findings. Category 3 also includes small ground-glass opacities that are not centrilobular (otherwise they would be CO-RADS 2) or not located close to the visceral pleura (otherwise they would be CO-RADS 4) [2,8].

CO-RADS 4 implies a high level of suspicion for pulmonary lession resulting from COVID-19 based on CT findings that are typical for COVID-19 but exhibiting some overlap with other (viral) pneumonias. Findings are similar to those for CO-RADS 5 but they are not located in contact with the visceral pleura, nor are they located strictly unilaterally in a predominant peribronchovascular distribution or superimposed on severe diffuse preexisting pulmonary abnormalities [2,8].

CO-RADS 5. Based on standard CT results, CO-RADS 5 indicates a very high degree of suspicion for COVID-19 pulmonary involvement [9]. The findings associated with this category can be broken down into two groups: Mandatory features, which must be present in all cases, and confirmatory patterns of features. At least one confirmatory pattern must be present [10]. Mandatory features are ground-glass opacities with or without consolidations in lung regions close to visceral pleural surfaces, including the fissures, and a multifocal bilateral distribution. Subpleural sparing can be present [2]. There are three confirmatory patterns that emerge at various times during the disease's progression. At an early stage, this pattern presents multiple ground-glass areas, which can be rounded or half-rounded in shape and have unsharp demarcation, or multiple and sharply limited ground-glass areas outlining the limits of multiple adjacent secondary pulmonary lobules. Later in the disease's progression, visible intralobular interstitial thickening combined with ground-glass opacities forms a "crazy paving" pattern. Later, the pattern

changes to one compatible with organizing pneumonia, which includes the reversed halo sign, ground-glass consolidation associated with extensive subpleural consolidations and an air bronchogram, curvilinear subpleural bands, and ground-glass bands with or without consolidation, but with an arching pattern with pleural contact [10].

CO-RADS 6 was introduced to classify COVID-19 that had been confirmed by a positive RT-PCR test for virus-specific nucleic acid (Figure 1) [9].

Discussion

COVID-19 has now posed a major threat to public wellbeing, the social health sector and remains a global challenge [11]. In this case, Coronavirus, which is highly contagious, must be diagnosed quickly and accurately in order to begin adequate therapy, restrict further virus transmission, and effectively remove the virus from circulation [12]. The standard norm for COVID-19 detection is RT-PCR of viral nucleic acid, although, current reports have acknowledged the relevance of chest CT scans analysis in COVID-19 patients with false negative RT-PCR findings, especially, when there is a clinical suspicion of infection [13-15]. Chest CT features, as bilateral involvement, subpleural or peripherally distributed GGO, consolidation, reticulation, crazy paving pattern, air bronchogram signs, intralobular septal thickening, pulmonary vascular enlargement [16-18, 19-25], are considered to be characteristic manifestations of COVID-19 infection [26] and with a high sensitivity [4,27] may let suspect this infection both in symptomatic and in some cases asymptomatic patients [28]. However, some lately published meta-analyses, evaluating accuracy of CT scans detecting COVID-19 pulmonary involvement, points out a risk of a low specificity and false-positive findings also [27, 29]. Dutch Radiological Society presented CO-RADS reporting model declares high predictability of COVID-19 in patients with moderate to severe symptoms [2], leading to the importance to evaluate this assessment tool and see whether a standardised model will provide more specificity and sensitivity into the practice. By using chest CT images of Japanese data to detect COVID-19 pneumonia, Fujioka et al. reported that CO-RADS retains significant efficiency and great interobserver consensus with average sensitivity of 87.8%, specificity of 66.4%, and an AUC of 0.859 [8]. Other retrospective study in Italy demonstrated high diagnostic accuracy and moderate interrater consensus among readers of varying skill levels with even higher than previous report specificity of 81%, but lower sensitivity of 61% and an AUC of 0.72 [30]. Dutch themselves measured the real-life performance of radiologist emergency department chest CT interpretation for tracing COVID-19, using CO-RADS and revealed a high precision of diagnosing with AUC of 0.87, especially when symptoms last longer

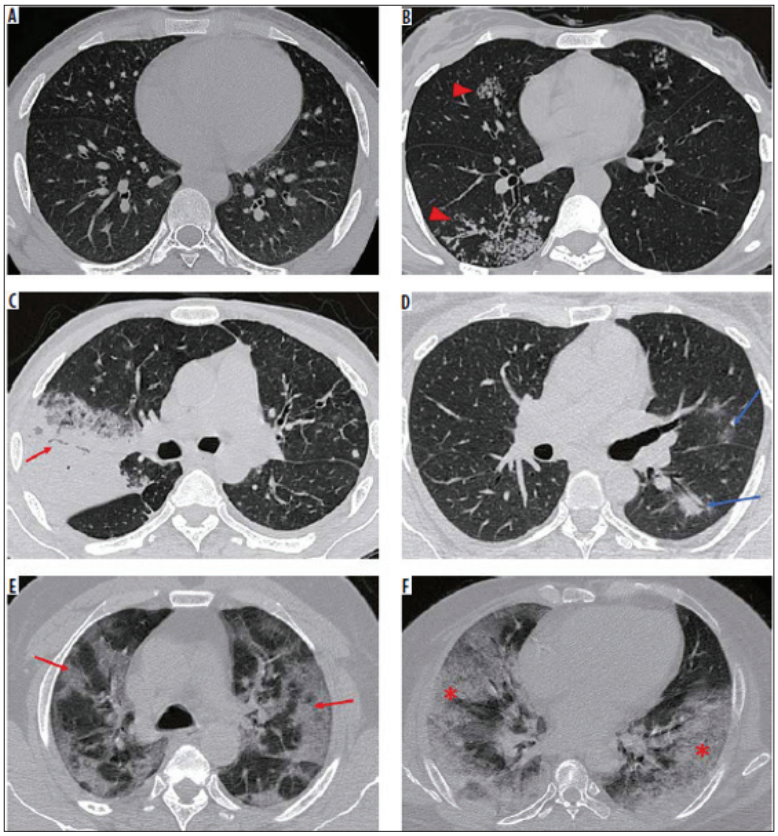

Figure 1. CO-RADS is depicted in representative axial high-resolution computed tomography (HRCT) chest images [36]:
A) CO-RADS 1 – normal HRCT chest;
B) CO-RADS 2 – centrilobular nodules in the right lung with a tree-in-bud configuration (red arrowheads) – bronchiolitis, later diagnosed as active pulmonary tuberculosis;
C) CO-RADS 3 – In a patient with Klebsiella pneumonia, dense consolidation with air bronchogram (red arrow) and surrounding ground-glass opacity (GGO);
D) CO-RADS 4 - left lung peribronchovascular GGOs (blue arrows);
E) CO-RADS 5 – peripheral and subpleural predominant multifocal GGOs with interlobular septal thickening – „crazy paving" pattern (red arrows) in both lungs. This was later identified as COVID-19 pneumonia;
F) A patient with acute respiratory distress syndrome due to COVID-19 pneumonia had extensive, peripheral confluent bilateral GGOs with septal thickening .

than 48 hours [31]. Another retrospective analysis of the practical use of CO-RADS in the emergency department of patients with possible COVID-19 infection also showed a great sensitivity and specificity of CO-RADS at 83.8% and 78.6%, respectively, with an AUC of 0.890 and provided a better risk classification by 65.8% in patients affected and by 82.1% in patients not affected by COVID-19 [26]. A study made by Özel et al. in Turkey to assess CO-RADS model agrees with Dutch Radiology society findings by discovering this reporting scheme being incredibly effective in detecting COVID-19 pneumonia, especially, CO-RADS 5, which suggests a very high probability for infection and statistically significant correlation with RT-PCR results [32]. A comparison analysis of CO-RADS scale and severity scoring system (CT-SS), suggested by Yang at al. [33], of predicting severe COVID-19 disease revealed both providing great performance with an AUC of 0.97 and 0.89, respectively, and CO-RADS scale giving even a better capability, with specificity of 98% at cut-off point > 4.5, sensitivity of 88% [34]. Showing a great standardised reporting model sensitivity and specificity by previous studies Lessmann et al. introduced an artificial intelligence (AI) system to rate the probability of COVID-19 pulmonary involvement on CT scans by using CO-RADS and CT severity scores, providing high patients with COVID-19 identification results with an AUC of 0.95 in an internal cohort and an AUC of 0.88 in an external cohort [1]. Some analysis indicate that CT imagining could be addressed for COVID-19 screening, thorough assessment, and follow-up, especially in epidemic areas with high pre-test disease probability [26] and combining it with a predictive assessment and reporting system could further improve the accuracy of diagnosing the COVID-19 pneumonia [35].

In conclusion, chest CT scan has a high sensitivity for COVID-19 diagnosis and could reduce false negative results obtained from RT-PCR tests. Furthermore, a standardized reporting system could increase clarification, minimize reporting variability and help radiologists recognize the results they observe, especially, for less experienced specialists.

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COVID-19 CO-RADS SKALĖS PRITAIKOMUMAS ABIPUSĖS PNEUMONIJOS KOMPIUTERINĖS TOMOGRAFIJOS DIAGNOSTIKAI

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Raktažodžiai: COVID-19, pneumonija, kompiuterinė tomografija, CO-RADS, SARS-Cov-2.

Santrauka

Kompiuterinės tomografijos (KT) tyrimas yra itin svarbus kriziniais momentais diagnozuojant COVID-19 infekciją. CO-RADS sistema yra penkiabalė krūtinės KT vaizdų sistema, kuri padeda standartizuoti COVID-19 infekcijos vertinimą ir atsakymo pateikimą [2].

Tyrimo tikslas – apibendrinti ir pateikti COVID-19 CO-RADS skalės svarbą abipusės pneumonijos kompiuterinės tomografijos diagnostikai.

Metodai. Literatūra šiai apžvalgai buvo rinkta naudojant Lietuvos sveikatos mokslų universiteto prenumeruojamas duomenų bazes: Medline (PubMed), SpringerLink ir ScienceDirect. Buvo nagrinėjami neseniai publikuoti moksliniai straipsniai, vertinantys COVID-19 CO-RADS skalės pritaikomumą abipusės pneumonijos kompiuterinės tomografijos diagnostikai.

Rezultatai. Krūtinės ląstos KT pakitimai, tokie kaip abipusis plaučių įtraukimas, subpleuriškai ar periferijoje išsidėstę solidiniai ar matinio stiklo židiniai, tinklelio požymis, netvarkingo grindinio vaizdas, oro bronchogramos, intraskiltelinių pertvarų sustorėjimas, plaučių kraujagyslių padidėjimas, laikomi būdingais COVID-19 ligos požymiais. Tyrimai rodo, kad olandų radiologų draugijos pristatytos CO-RADS skalės jautrumas ir specifiškumas varijuoja (atitinkamai) tarp 61-88 ir 66,4-98 procentų.

Išvados. Krūtinės ląstos KT tyrimas pasižymi gan dideliu jautrumu diagnozuojant COVID-19 ligą ir galėtų sumažinti klaidingai neigiamus rezultatus, gautus atliekant RL-PGR testus. Standartizuota sistema turėtų suteikti daugiau aiškumo, sumažinti pranešimų kintamumą ir padėti radiologams, ypač mažiau patyrusiems, daug greičiau atpažinti šiai infekcijai būdingus pakitimus.

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