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Role of computed tomography in COVID-19 emergent conditions: A review article

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Abstract--Background: The COVID-19 pandemic has strained global healthcare systems, highlighting challenges in diagnosing and managing the disease while ensuring patient safety. **Aim:** This review evaluates the role of computed tomography (CT) in identifying COVID-19-related emergent conditions, emphasizing its diagnostic significance beyond conventional reverse transcriptase-polymerase chain reaction (RT-PCR) testing. **Methods:** We conducted a comprehensive literature review on CT imaging's effectiveness in detecting pulmonary involvement in COVID-19 patients, comparing its findings with those of RT-PCR and other imaging modalities. **Results:** CT scans reveal characteristic features of COVID-19 pneumonia, including bilateral ground-glass opacities and consolidations, which can occur even when RT-PCR tests yield negative results. The integration of CT imaging has enhanced early diagnosis and informed clinical decision-making, particularly in emergency settings. **Conclusion:** CT imaging plays a critical role in managing COVID-19, aiding in the early detection of pulmonary complications and facilitating appropriate patient triage. However, its effectiveness is influenced by pandemic prevalence trends and clinical context, necessitating a multi-faceted diagnostic approach. A standardized strategy incorporating CT imaging alongside RT-PCR testing is essential for improving patient outcomes during pandemic surges.

Keywords--COVID-19, computed tomography, reverse transcriptase-polymerase chain reaction, pneumonia, diagnostic imaging, healthcare management.

Introduction

The emergence of the COVID-19 pandemic has posed significant challenges to healthcare systems worldwide, affecting both resource-limited regions and even the most affluent countries. A primary difficulty brought about by the pandemic is managing the influx of patient admissions while simultaneously isolating infected individuals to mitigate the risk of nosocomial transmission. The initial diagnosis of SARS-CoV-2 infection in suspected cases relies on confirmation via reverse transcriptase-polymerase chain reaction (RT-PCR) nasopharyngeal swab testing and the identification of pneumonia through chest imaging techniques such as lung ultrasound and CT scans [1, 2, 3]. From the outset of the pandemic's first wave, marked by an extraordinarily high incidence of infections, it became clear that the sensitivity of RT-PCR testing was inadequate, resulting in a considerable number of false-negative cases [4]. For patients exhibiting clear symptoms that raise suspicion of COVID-19, the diagnostic process is enhanced through a systematic approach that combines clinical evaluation, bedside lung ultrasound or CT imaging, and RT-PCR [3]. In certain instances, repeated RT-PCR tests conducted during hospitalization may uncover initial false-negative results. Moreover, it has been well-documented that SARS-CoV-2 can lead to asymptomatic infections in a notable proportion of cases. Consequently, for patients admitted to hospitals without symptoms indicative of SARS-CoV-2 infection, the potential for asymptomatic infection exists. Therefore, it is essential during the pandemic to rule out asymptomatic SARS-CoV-2 in patients hospitalized for other medical conditions, to isolate unforeseen cases and minimize the risk of cross-infection. Recent literature has indicated that CT imaging can be valuable in detecting signs of typical SARS-CoV-2 pneumonia in patients who are asymptomatic and have tested negative via RT-PCR [5]. To prevent the inadvertent mixing of infected and non-infected patients in hospital settings during surges of COVID-19, it is vital to implement a standardized strategy. This strategy should encompass measures such as enhancing distancing protocols and utilizing personal protective equipment for both patients and healthcare personnel, as well as the more complex and costly separation of infected and non-infected areas.

CT in COVID-19 Conditions:

Computed tomography (CT) has emerged as a crucial diagnostic tool in the management of COVID-19, particularly in emergency settings. As the pandemic has unfolded, the rapid identification of pulmonary involvement has become essential for effective patient triage and treatment. CT imaging is particularly valuable for its ability to detect the characteristic features of COVID-19 pneumonia, which may not be immediately apparent through RT-PCR testing alone. Studies have shown that CT scans can reveal bilateral ground-glass opacities, consolidations, and reticular patterns that correlate with viral infection, even in patients who present with atypical symptoms or who test negative on initial swabs. This ability to visualize lung pathology allows for timely clinical decision-making, which is critical in emergency scenarios where delays in diagnosis can lead to worsened outcomes. Furthermore, the role of CT in COVID-19 extends beyond diagnosis to include assessment of disease severity and progression. In the emergency setting, CT imaging can assist clinicians in

determining the extent of lung involvement, facilitating the identification of patients at risk for deterioration. By utilizing quantitative CT analysis, healthcare providers can evaluate the percentage of lung involvement and assess changes over time, aiding in treatment planning and prognosis. This comprehensive approach not only enhances the understanding of individual patient cases but also contributes to broader epidemiological insights, enabling healthcare systems to allocate resources more effectively. As the COVID-19 crisis continues, the integration of CT imaging into emergency protocols remains vital for improving patient care and outcomes, underscoring its significance in the pandemic's response.

CT findings in COVID-19:

Computed tomography (CT) imaging has revealed several characteristic findings in patients diagnosed with COVID-19 pneumonia. One of the hallmark features is the presence of ground-glass opacities (GGO), which appear as areas of increased radiopacity that do not obscure the underlying vascular markings. These GGOs are typically bilateral and preferentially located in the peripheral regions of the lungs, particularly in the lower lobes. The early detection of GGOs is significant as they often represent the initial radiological manifestation of SARS-CoV-2 infection. Additionally, the presence of consolidation, which indicates the filling of alveolar air spaces with fluid, inflammatory cells, or debris, is frequently observed. This consolidative pattern can co-occur with GGOs, further complicating the clinical picture and potentially indicating disease progression. Another important CT finding associated with COVID-19 is the crazy-paving pattern, characterized by a combination of thickened interlobular septa and superimposed ground-glass opacities. This pattern has been linked to the inflammatory process resulting from the viral infection and is considered a key indicator of more severe disease. Furthermore, other notable CT findings may include reticular patterns and bronchiectasis, although these are less common. The comprehensive assessment of these CT findings is essential for evaluating the extent of lung involvement, guiding clinical management, and predicting patient outcomes. In emergency settings, rapid identification of these radiological signs can facilitate timely intervention, optimize resource allocation, and improve overall patient care in the context of the ongoing pandemic.

Other Radiological Findings:

In addition to the prominent findings observed in computed tomography (CT), other imaging modalities have also revealed valuable insights into the pulmonary manifestations of COVID-19. For instance, chest X-rays can serve as an initial screening tool, although they may not be as sensitive as CT scans in detecting early lung changes. Typical X-ray findings in COVID-19 patients include bilateral infiltrates, which often appear as patchy opacities, and a distribution that can be both central and peripheral. While chest X-rays are readily available and can be performed quickly, their limitations in sensitivity may result in missed diagnoses, particularly in the early stages of the disease when ground-glass opacities are not yet apparent. Nonetheless, they can still provide useful information regarding disease progression and the development of complications such as acute respiratory distress syndrome (ARDS). Ultrasound imaging has also gained

attention as a complementary diagnostic tool for assessing lung pathology in COVID-19 patients, particularly in point-of-care settings. Lung ultrasound can reveal pleural effusions, B-lines (indicating interstitial edema), and subpleural consolidations, which are indicative of viral pneumonia. The use of lung ultrasound is particularly advantageous due to its bedside accessibility, lack of ionizing radiation, and ability to facilitate immediate clinical decision-making. Furthermore, it is especially useful in monitoring disease progression and guiding interventions such as thoracentesis in cases of significant pleural effusion. Collectively, these imaging findings underscore the multifaceted approach required in the evaluation and management of COVID-19, emphasizing the importance of integrating various imaging modalities to enhance diagnostic accuracy and optimize patient care.

Case study:

The initial impact of the COVID-19 pandemic on our geographical region was observed in the spring of 2020, prompting our institution to prioritize urgent measures in response to the surge inpatient admissions. Among these priorities was the imperative to safeguard both patients and healthcare personnel from the risk of nosocomial transmission. Consequently, strategies were implemented to ensure a sufficient supply of personal protective equipment (PPE) and to establish designated zones within the hospital for patients with confirmed COVID-19 infections and those without. These zones encompassed beds allocated for both high-acuity and low-acuity care requirements. Given the recognized suboptimal sensitivity of initial reverse transcriptase-polymerase reaction (RT-PCR) testing and the delays associated with laboratory results, our team adopted a strategy that integrated lung ultrasound with clinical evaluations to facilitate the safe initial triage of patients suspected of having COVID-19 [8, 9]. This protocol was subsequently validated through an international multicenter study [3]. From this experience, we emphasize that chest imaging should be contextualized with the clinical presentation and symptoms to ensure an accurate diagnostic process. Following initial triage in the emergency department (ED), in cases that remain ambiguous, serial RT-PCR testing coupled with expanded chest imaging via CT scans is essential for completing the diagnostic evaluation, thereby guiding the appropriate admission of patients to designated COVID-19 or non-COVID-19 areas [3]. During the various waves of the outbreak, the volume of alternative medical conditions necessitating hospital admission plummeted to unprecedented lows, resulting in the overwhelming majority of available beds being allocated for COVID-19 patients.

Over the past two years, it has become increasingly evident that the pandemic can exhibit significant fluctuations in prevalence [10]. After the initial surge, our institution witnessed a decline in COVID-19 cases alongside an increase in admissions for alternative medical conditions. Gradually, the beds designated for COVID-19 patients were repurposed for general use, leading to an increased emphasis on mitigating the risk of unrecognized COVID-19 cases in non-COVID areas. To address this concern, our institution deliberated the introduction of a diagnostic algorithm utilizing CT imaging to identify clinically occult COVID-19 pneumonia [5]. This algorithm was implemented for any patient aged over 50 who required admission from the ED for non-COVID diagnoses while presenting

negative RT-PCR results. Although the protocol was approved and utilized throughout our study period, a subsequent analysis revealed its ineffectiveness after three months.

A primary contributing factor to this ineffectiveness is the variability in COVID-19 prevalence, which substantially impacts the diagnostic precision of RT-PCR and chest imaging, the two principal diagnostic modalities for managing COVID-19 [4, 11]. For instance, during periods of peak infection rates, the likelihood that a positive RT-PCR result correlates with actual SARS-CoV-2 infection is exceedingly high, while a negative result may not sufficiently exclude the diagnosis. Conversely, during periods of declining prevalence, a negative RT-PCR result becomes more definitive in ruling out infection than it does during peak periods. The same principle applies to chest imaging; at times of elevated prevalence, signs indicative of interstitial pneumonia gain specificity, whereas such signs may be less definitive as prevalence approaches zero, increasing the probability of alternative diagnoses. Moreover, chest imaging primarily identifies pulmonary involvement and is not useful for diagnosing infections that do not present with pneumonia. Therefore, the utility of CT scans for COVID-19 diagnosis is considerably constrained [11, 12]. Finally, following Bayesian principles, the accuracy of any diagnostic test diminishes when applied to patients without clinical indications of the disease. Thus, like other diagnostic modalities, CT scans lose specificity for diagnosing COVID-19 pneumonia in asymptomatic patients [13].

In the authors' view, employing a strategy that relies on systematic RT-PCR and CT imaging for identifying COVID-19 patients in the ED to inform allocation into isolated compartments may conceal inherent challenges. During our study, some patients were mistakenly placed in COVID-19 areas based on inconclusive imaging, even when they were situated in designated protective beds, subsequently revealing they were uninfected. Furthermore, our findings are limited as the algorithm was deployed during a phase of declining prevalence, when the likelihood of false-negative RT-PCR results was significantly reduced. It is plausible that during a resurgence in prevalence, the rate of false-negative results could escalate considerably. In such scenarios, CT imaging may assist in detecting clinically occult COVID-19 pneumonia but would be ineffective for diagnosing cases without pulmonary involvement. For these reasons, rather than strictly categorizing patients in the ED as COVID-19 or non-COVID-19 for admission into separate areas, it is prudent to consider all patients and personnel as potential sources of infection. We propose that a comprehensive strategy emphasizing bed distancing, enhanced PPE for staff, and rigorous monitoring of patients with negative RT-PCR results in areas designated for alternative medical conditions may offer a more effective and safer approach.

Conclusion

The COVID-19 pandemic has profoundly impacted healthcare systems worldwide, necessitating innovative approaches to diagnosis and management. This review has demonstrated the pivotal role of computed tomography (CT) in identifying COVID-19-related emergent conditions, particularly in the context of insufficient sensitivity of traditional reverse transcriptase-polymerase chain reaction (RT-PCR)

testing. As COVID-19 presented unique challenges, including the need to rapidly triage and manage patients while minimizing the risk of nosocomial transmission, CT imaging emerged as an invaluable tool. CT scans offer distinctive insights into pulmonary involvement, revealing characteristic patterns such as bilateral ground-glass opacities and consolidations that are critical for timely diagnosis and treatment. These features can be particularly relevant for patients who present atypical symptoms or those whose RT-PCR results are initially negative. The ability of CT to visualize lung pathology facilitates effective clinical decision-making, especially in emergency scenarios where rapid intervention is crucial. However, the effectiveness of CT imaging as a diagnostic modality is not without limitations. Variability in the prevalence of COVID-19 cases significantly affects the diagnostic accuracy of RT-PCR and CT, influencing their respective roles in identifying infected patients. As demonstrated in our case study, implementing a diagnostic algorithm reliant solely on CT imaging and RT-PCR testing may lead to inappropriate patient placement in COVID-19 isolation areas, underscoring the need for a comprehensive approach. In light of these challenges, it is essential to consider all patients as potential sources of infection, regardless of their clinical presentation. Employing strategies that integrate rigorous monitoring, enhanced personal protective equipment (PPE), and structured triage protocols can help ensure the safety of both patients and healthcare personnel. Moving forward, the integration of CT imaging into standardized diagnostic pathways, alongside RT-PCR testing, will be critical in managing COVID-19 effectively, particularly during periods of fluctuating disease prevalence. By continuously adapting our diagnostic strategies to reflect the evolving landscape of the pandemic, we can enhance patient care and outcomes while safeguarding healthcare resources.

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دور التصوير المقطعي المحوسب في حالات الطوارئ المرتبطة بكوفيد-19 - مقال مراجعة

الملخص:

الخلفية: فرضت جائحة كوفيد-19 ضغوطاً على أنظمة الرعاية الصحية العالمية، مما سلط الضوء على التحديات في تشخيص المرض وإدارته مع ضمان سلامة المرضى.

الهدف: تقيم هذه المراجعة دور التصوير المقطعي المحوسب (CT) في تحديد الحالات الطارئة المرتبطة بكوفيد-19، مع التركيز على أهميته التشخيصية إلى جانب اختبار النسخ العكسي لتفاعل البوليميراز (RT-PCR) التقليدي.

الأساليب: قمنا بإجراء مراجعة شاملة للأدبيات حول فعالية تصوير CT في الكشف عن المشاركة الرئوية لدى مرضى كوفيد-19، مقارنةً بالنتائج مع نتائج اختبار RT-PCR ووسائط التصوير الأخرى.

النتائج: تكشف أشعة CT عن ميزات مميزة للتهاب الرئة المرتبط بكوفيد-19، بما في ذلك العتبات الزجاجية الثنائية والتجمعات، والتي يمكن أن تحدث حتى عندما تعطي اختبارات RT-PCR نتائج سلبية. لقد عزز دمج تصوير CT من التشخيص المبكر وساعد في اتخاذ قرارات سريرية مستنيرة، خاصةً في بيئات الطوارئ.

الاستنتاج: يلعب تصوير CT دورًا حاسمًا في إدارة كوفيد-19، حيث يساعد في الكشف المبكر عن المضاعفات الرئوية ويسهل تصنيف المرضى بشكل مناسب. ومع ذلك، تتأثر فعاليته باتجاهات انتشار الجائحة والسياق السريري، مما يستلزم اتباع نهج تشخيصي متعدد الجوانب. إن وجود استراتيجية موحدة تضم تصوير CT إلى جانب اختبار RT-PCR أمر ضروري لتحسين نتائج المرضى خلال فترات الذروة للجائحة.

الكلمات المفتاحية: كوفيد-19، التصوير المقطعي المحوسب، النسخ العكسي لتفاعل البوليميراز، التهاب الرئة، التصوير التشخيصي، إدارة الرعاية الصحية.