The Radiology Resident Experience at a Large Tertiary Care Hospital During the COVID-19 Pandemic

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ABSTRACT: The COVID-19 pandemic has created unprecedented challenges in healthcare including pressure to provide efficient and timely patient care while maintaining a safe environment for physicians and staff. Radiology plays a vital role as part of a multidisciplinary team in the care of these patients. We address the experiences of our radiology residency at a large urban US academic institution with an underserved population in our fight against COVID-19. The unprecedented challenges faced during this pandemic has created monumental impacts on our training and allowed for development of skills and resources in order to better handle future situations.

KEYWORDS: COVID-19, radiology, radiology residency, virtual learning, CT, workflow

Introduction
The pandemic of COVID-19 caught much of the healthcare world off guard and we, in radiology, were not exempt. What was once a theoretical discussion topic for us radiology residents, quickly morphed into our department’s and our institution’s primary focus with marked workflow and space alterations, several dedicated lectures, a plethora of emails, and then to seeing an onslaught of cases in a short matter of 10 days.

As residents, March 10th, 2020 was our first formal clinical introduction to COVID-19 when the United States had 472 confirmed cases and the virus was plaguing Washington State with 19 deaths.1

During that morning’s conference we watched the Society of Thoracic Radiology COVID-19 position statement titled; “COVID-19 Update for the Radiologist” by Jeffrey Kanne, MD.2 The lecture was an encompassing overview on the history of Coronavirus (ie, SARS and MERS), their epidemiology, and the characteristic radiographic features of COVID-19. By the next day, on March 11th, the radiology department had a joint conference with the pulmonology department to review the clinical protocols, patient and imaging logistics, and standardized reporting conduct with respect to COVID-19 imaging. Within the next week the residency had been drastically restructured with a view to minimize exposure to the residents whilst gauging workload requirements. Regular stations were replaced by a skeleton crew of residents and attendings to create social distancing as the first few cases of COVID-19 started trickling in at our main academic hospital.

Our workflow was in constant flux as our department chair and hospital leadership worked in tandem to provide for the evolving needs of both our patients and healthcare teams. With the growth of COVID-19 patient volume in Philadelphia, our processes evolved rapidly to coincide with changes in the medical management of COVID-19. Our hospital established a “hospital within a hospital” design which is unique to the Philadelphia environment. In this manner we rapidly relocated all outpatient services from a specific pavilion (a separate building of our hospital) and made this the “COVID-19 only” hospital. Leading the COVID-19 charge was the pulmonology department and they wanted rapid reporting of imaging results from patients entering the emergency department for appropriate disposition to either home, the main hospital, or “COVID-19 only” hospital. Initially, serologic testing was either not available or took 4-5 days to gain results, our institution needed to triage based on degree of suspicion. A decision tree was worked and reworked to largely rely on a combination of symptomatology plus imaging findings of chest CT for disposition (Figure 1).

As residents, our immediate goals were to continue providing excellent patient care in a rapidly evolving clinical and epidemiological setting. It was of prime importance for us to keep abreast of new evidence regarding the imaging manifestations of the viral infection all while staying safe and healthy to contribute to the effort against COVID-19. This has been ever more essential as Philadelphia has become a “hot spot” for the COVID-19 contagion and our institution has seen the highest volume of cases in our region.3

Resident Adaptation in the Face of a Pandemic
Initially, cases of COVID-19 were sparse, numbering a few per day and many residents were hesitant and unsure of making this diagnosis. We found the Review and Commentary Perspective “Chest CT Findings in 2019 Novel Coronavirus (2019-nCoV) Infections from Wuhan, China: Key Points for the Radiologist” by Jeffrey Kanne especially helpful for us to get a sense for how COVID-19 pneumonia presents before cases at our own institution began to rise.4 Initial radiographic reports out of China and Italy described

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chest CT findings of COVID-19 as highly nonspecific multifocal ground glass opacities seen bilaterally, with features of organizing pneumonia at around 9-13 days. Pleural effusion, cavitation, pulmonary nodules, and lymphadenopathy were not reported to be associated with COVID-19.\textsuperscript{5,6} However, at our institution; a large, urban tertiary care center that cares for an extremely underserved population and holds the title of the nation’s largest lung transplant program, we started seeing not only a much higher volume of cases, but cases of COVID-19 superimposed on patients with chronic cardiopulmonary disease and transplanted lungs. This is where our extensive training in chest radiology has been extremely advantageous for us as we have the knowledge base as well as experienced thoracic radiologists to discern whether the radiographic findings were due to COVID-19 versus post-transplant complications, other atypical infections, or chronic disease process exacerbations.

At our institution, it was imperative for both residents and faculty to rapidly become proficient at diagnosing and triaging COVID-19 cases as we are a resident centered radiology program that employs resident coverage 24/7 without fellow assistance. Additionally, our program utilizes a third shift overnight in-house resident coverage system with nighthawk support. The resident’s responsibility is to dictate all preliminary reads and directly call the caring provider to give rapid real time information so that proper precautions can be put into place. Initially, we were asked to call the primary team taking care of the patient, the designated infectious disease consultant, and the designated pulmonology consultant when a scan had a positive result. This procedure of calling three separate providers proved to be extremely inefficient and time consuming as the consulting physician usually had not seen the patient yet or even been consulted. We started only calling the primary team taking care of the patient to efficiently relay the essential findings so that precautions and triage could be taken in a timely manner.

Figure 1. Decision tree for the triage and admission of suspected COVID patients based on CT imaging findings.
A rapid new order set and Picture Archiving and Communication System (PACS) integrated workflow was also created to assist. Orders for suspected COVID-19 cases were made and implemented as a special “CT Viral Airborne Screening” protocol designed for prioritizing cases of suspected COVID-19 patients. The protocol includes axial and coronal lung kernels with a 3 mm slice thickness. We established a color coded “STAT COVID-19” work list visible on PACS to rapidly identify these cases. A goal was established to complete a COVID-19 chest CT and place a preliminary read within 5 minutes. We have been able to meet this goal with high efficiency with our residents fully trained in interpreting these scans. Small changes such as these which were borne from resident input created a more streamlined environment which directly improved our resident workflow and allowed us to increase our reading efficiency to meet the escalating demands.

**Radiology Residents Contributing to a Multidisciplinary Team Effort**

Due to the rapidly evolving nature of the pandemic, there were immediate changes made to the work structure in order to incorporate a multidisciplinary approach to COVID-19 management. Initial efforts were made to integrate major disciplines which included radiology, pulmonology, emergency medicine and internal medicine. Priority was established for prompt triage of the suspected COVID-19 patients in order to better expedite care. As with any rapidly evolving emergent situation, prompt and efficient communication between specialties became the hallmark of this new approach.

Although many academic bodies and radiologic societies debated the utility of screening CT studies for the identification of COVID-19 pneumonia, our providers found meaningful and quick clinical input using CT to efficiently streamline the triage process. In order to unify reporting, we adopted universal terminology for stratifying CT findings in terms of suspicion for atypical or viral pneumonia (ie, COVID-19). The creation of a standardized reporting system resulted in expedited triage for clinical teams. This streamlined process ensured effective and efficient multidisciplinary care and allowed for better allocation of precious resources (ie, N95 masks, respirators, and isolation gowns).

Working closely with the hospital administration and the department of pulmonology, the radiology department created a standardized process for imaging patients with clinical suspicion for COVID-19. We have provided our clinicians with a unique simplified chest CT order for patients exhibiting symptoms of COVID-19. This order directs the patient to a dedicated CT scanner, physically located in the “COVID-19 only” hospital building, and alerts all personnel involved in obtaining the CT scan to don appropriate PPE. The scanner is then decontaminated by a dedicated sanitization team after the examination. This system has proved to be a simple yet effective way for our colleagues on the floor to obtain imaging of suspected COVID-19 patients while minimizing exposure risk and facilitating rapid dissemination of information.

**Resident Education**

Just as the impact of the COVID-19 pandemic has presented several challenges to the resident workflow, so too this impact was felt by the resident education. Under normal circumstances, the radiology residency education curriculum is centered around in-person teaching conferences which are usually held twice a day and consists of both didactic lectures and case conferences. Residents are also typically encouraged to attend and participate in a variety of recurring interdepartmental conferences. However, in order to reduce potential exposure and transmission of COVID-19, social distancing measures inevitably required changes to the traditional resident education to be made.

Several in-person conferences and meetings were canceled or postponed, however, many were transitioned to Zoom conferences. In addition to these changes, residents were provided with online educational resources including pre-recorded lectures and review articles to supplement learning. There were initial concerns regarding moving our lectures to a predominantly online education revolting around worries that the educational experience would not be robust as our traditional in-person lectures. Normally, it is easy for an attending physician to interact with us 24 residents who are present within a lecture hall for questioning and discussion during lecture. Initially, we found it difficult for the lecturers to engage with residents as an audience over Zoom conferences. This was overcome by incorporating web-based audience response systems (ie, polls or multiple choice questions) to encourage active resident participation. Additionally, over time, us residents and our attendings felt more comfortable with the technology and lecture format, which improved resident participation. Ultimately, a majority of the residents in the program have found the new online learning system to provide an education on par with the previous in person learning experience.

The total number of imaging examinations and procedures also decreased due to reduced outpatient throughput. In accordance with the Center for Disease Control and Prevention (CDC), the American College of Radiology (ACR) supported the guidance to reschedule any non-urgent outpatient imaging visits to help control infection risk. The resultant fewer number of imaging studies inherently posed another obstacle for resident education. Residents were left with fewer cases to interpret and perform, ultimately providing a limited caseload to learn from.

**Social Media**

Digital engagement through the means of social media and online forums offers the unique ability to overcome the constraints of social distancing during quarantine. For us residents who grew up in the digital age, social media is an enormous
part of our daily life and has impacted the way we work, communicate, and express ourselves. Networking sites, such as Facebook and Twitter, as well as online forums prove useful towards remaining connected to one another. They provide a channel for the exchange of information, offer insight into coping mechanisms, and allow us to share strategies to deal with the uncertainty of the evolving pandemic. Therefore, for some, social media served not only as a source of news, but also a sense of community and help preparedness.

Resident Safety and Preparedness
From the onset of this crisis, resident safety and preparedness was, of course, a top priority at our institution. As residents, we are on the front lines caring for patients with COVID-19. A healthy resident workforce is paramount in ensuring there are enough providers to tend to the growing as of yet unknown number of patients who are and will suffer from this infection. At our institution, resident safety was tackled in a two pronged approach. The first was to minimize the potential for physical resident exposure to COVID-19 and the second was to teach residents best practices in order to minimize risk for infection while working at the hospital.

In order to minimize the potential for resident exposure to COVID-19, the department created a schedule allowing for a significant percentage of residents and faculty to work from home. This reduced the number of people physically present in the reading rooms to better allow for safe social distancing. This was accomplished by providing faculty with home work stations en-masse and establishing protocols for residents to review cases with attending radiologists remotely. To review cases with our attending radiologists we utilized the Zoom screen share function which allowed us to speak to and view each other’s computer screens which was an extremely efficient way to remote review cases together. Finally, clear guidelines were established to ensure that residents working off site were always able to be contacted by the faculty and were available to report to the hospital in less than one hour if need be. These standardized routes of communication between residents and faculty also ensured that residents were informed of any changes in hospital policy or the radiology department’s response to the COVID-19 pandemic in real time.

The reduced workload allowed us to pare down the number of residents physically in house each day, thus providing a pool of residents who could be called upon to fill in for their peers if and when they became ill or quarantined. Additionally, residents who were on services with severe reductions in volume, such as mammography, were temporarily moved to busier sections, such as chest radiography.

In addition to creating a plan for reducing the number of personnel in the reading rooms, hospital administration and the department established protocols to reduce the exposure risk to the residents who are present on the hospital campus. All hospital staff are given a surgical mask and have their temperature taken daily when entering the hospital. Instruction and materials have been provided for faculty and staff on how to disinfect work stations at the start and end of each shift. Additionally, signs have been placed on the front of each reading room door with our contact numbers, encouraging our clinicians to contact us via telephone rather than in person to discuss cases.

While the crisis created by the COVID-19 pandemic is unprecedented in the world of modern medicine, there is however precedent for general crisis management. Much of this precedent is derived from the world of business, where crises are not uncommon and a substantial amount of research and thought has been devoted to the handling of crises. According to Clark and Harman (associates at the Atlanta, Ga based firm Crawford & Company), the first principle of crisis management is "not about researching and planning contingencies for every possible crisis that might occur but rather about developing the capability within the organization to react flexibly. . .".10 In accordance with this principle, our department rapidly implemented changes to provide the highest quality care for our patients and assistance to our clinical teams while minimizing the exposure risk to our residents. Additionally, we continuously reviewed our response to this crisis and continue to make changes in the way we practice, in order to best adapt to this rapidly changing landscape of the COVID-19 pandemic.

Conclusion
The unique and unprecedented situation created by the COVID-19 pandemic has taught us, as residents, to acknowledge the importance of adaptability and clear and efficient communication. As the pandemic unfolded, we were forced to quickly develop a solid knowledge base of COVID-19 radiographic findings and strategize an effective reporting system so that accurate information could be succinctly reported to the primary providers. In this role, we became an integral part of the multidisciplinary health care team and allowed us to deliver quality care to our patients.

The environment also pushed us to collaborate with hospital administration to implement several residency changes such as online platform learning and social distancing, as to preserve resident education and to promote safety. Residents and administration drew insight from nontraditional resources such as social media and online fora in developing organizational policies during the rapidly changing nature of the pandemic. As such, we learned that a quick organizational effort that has clear goals with a flexible approach to delivery is essential for transparency and quick dissemination of developing information.

The COVID-19 pandemic has created hardships on us as radiology residents and healthcare providers, but has also given us the skills to adapt and rise to future challenges that will undoubtedly present themselves.
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MK conceived the idea for the project and assisted in editing the manuscript. JH, KR, AC, TS, HM, and GC wrote and edited the manuscript.

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