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Coronavirus Outbreak: Is Radiology Ready? Mass Casualty Incident Planning

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Abstract

On March 11, 2020, the World Health Organization declared a coronavirus disease 2019 (COVID-19) pandemic. Health care systems worldwide should be prepared for an unusually high volume of patients in the next few weeks to months. Even the most efficient radiology department will undergo tremendous stress when victims of a mass casualty flood the emergency department and in turn the radiology department. A significant increase is expected in the number of imaging studies ordered for the initial diagnosis and treatment follow-up of cases of COVID-19. Here, we highlight recommendations for developing and implementing a mass casualty incident (MCI) plan for a viral outbreak, such as the current COVID-19 infection. The MCI plan consists of several steps, including preparation, mobilization of resources, imaging chain, adjusting imaging protocols, and education, such as MCI plan simulation and in-service training. Having an MCI plan in place for a viral outbreak will protect patients and staff and ultimately decrease virus transmission. The use of simulations will help identify throughput and logistical issues.

Key Words: Coronavirus, COVID-19, mass casualty, novel COVID-19-infected pneumonia, preparedness, radiology

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INTRODUCTION

It is 2 AM on a busy Saturday night, and you are the only radiologist in house; you receive a call from the emergency department. "We have 15 patients that we suspect have the coronavirus, and we are sending them to CT now for diagnosis." You call the CT technologist and ask how many technologists are in house for the four CT scanners that are available. The technologist responds, "Just me." You know the CT image acquisition will not take much time, but how much time is needed to transport each patient and clean the CT scanner, in addition to the extra time for the CT technologist to adhere to standard, droplet, and airborne precautions? How

will this affect patient throughput for trauma, stroke, and emergent surgical cases?

This scenario illustrates the importance of involving the radiology department in a hospital's mass casualty incident (MCI) plan. An MCI is an event that overwhelms a hospital's available resources, both structural and technological [1]. Conventionally, this would include terrorist attacks, bombings, mass shootings, and natural disasters. An infectious disease outbreak, however, could also quickly exhaust a hospital's resources. In the case of a viral outbreak such as the coronavirus disease 2019 (COVID-19), the inciting event leads to a more protracted course of resource use and depletion. Radiologists can play an important adjunct role in triaging and diagnosing patients during a MCI, including a COVID-19 outbreak. Even the most efficient radiology department will undergo tremendous stress when victims of a mass casualty flood the emergency department and in turn the radiology department. This plan will answer many of the questions that affect the radiology response for the emergency department and inpatient

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Visual abstract

Viral Outbreak: Mass Casualty Incident Planning in Radiology

STEP 1

Work with your hospital's
Emergency Medicine Leadership

Request the institution's mass casualty plan, specifically for a viral outbreak.



Create ordering algorithms for specific circumstances to increase overall throughput of essential imaging.

STEP 2

Plan for Patient and Staff Safety



Coordinate with the hospital's environmental services team for procedures and time needed for cleaning stationary rooms (CT, MRI, and X-Ray).



STEP 3

Keep Adapting



Policy and procedures may need to change quickly to meet immediate needs of patients. Communicate clearly with section heads to spread information quickly.

A mass casualty plan will protect patients and staff in case of a viral outbreak and ultimately decrease virus transmission.

JACR VISUAL ABSTRACT

imaging, but it is not tailored toward planning or discussion of challenges in the workflow of outpatient imaging.

Although some patients will contract the virus from close contact with symptomatic individuals, others will contract COVID-19 from a population that is asymptomatic. In the health care setting, this can include patient-to-patient, patient-to-staff, and staff-to-patient transmission, if strict precautions are not followed [2]. As more symptomatic patients seek medical care for coronavirus infection in an outbreak scenario, hospital resources will progressively be diverted away from those patients not affected by the disease.

GLOBAL CRISIS

In late December 2019, an outbreak of a novel coronavirus (SARS-Cov-2) was announced in Wuhan, China [3]. Although rigorous attempts were made to confine the disease, this infection has continued to spread throughout the world. At the date of this publication, there are confirmed COVID-19 cases in 162 countries worldwide with growing concern that the infection will quickly reach pandemic proportions. As per Bruce Aylward, head of a World Health Organization expert mission to China, the world is "simply not ready" to contain this outbreak [4]. China's extraordinary measure of instituting a quarantine in Wuhan and surrounding areas afforded the world a few months of lead time to prepare. However, according to

Tom Frieden, MD, the former director of the US Centers for Disease Control and Prevention, a coronavirus pandemic is inevitable [5]. The number of confirmed cases and patient deaths from COVID-19 has already exceeded those of severe acute respiratory syndrome and Middle East respiratory syndrome [6].

Health care systems worldwide should be prepared for an unusually high volume of patients in the next few months. This will include patients with COVID-19 in addition to patients requiring emergent care for other illnesses. Rapid diagnosis is essential for efficient patient triage. The reverse transcription polymerase chain reaction (RT-PCR) test kits disseminated by the Centers for Disease Control and Prevention are considered the gold of standard for COVID-19 diagnosis [7], but several studies have shown that a negative initial result does not exclude COVID-19 infection [8,9]. Additionally, it may take up to 48 hours to receive the final results, which limits the utility of this diagnostic test during initial triage of these patients in the emergency setting. In a recent study published in *Radiology*, based on a retrospective study of 1,014 patients, the diagnostic sensitivity of chest CT for COVID-19 is significantly greater than that of RT-PCR (98% versus 59%), but the specificity is limited (25%) [7]. Proposed explanations for the decreased sensitivity of RT-PCR include low viral load, immature development of RT-PCR technology, and suboptimal clinical sampling. This study concluded that chest CT

can be used as a screening tool for COVID-19 in cases with a high pretest probability, as evidenced by patients demonstrating clinical manifestations compatible with COVID-19 infection. Therefore, it is expected that there will be a significant increase in the number of imaging studies ordered for suspected cases of COVID-19 from both emergency medicine department and inpatient services. Given the low specificity of CT for diagnosing COVID-19, the ACR does not recommend the use of CT for screening or as a first-line test for diagnosing COVID-19 [10].

MCI PLANNING: VIRAL OUTBREAK

Creating an MCI plan for a radiology department can be a daunting task. In the following discussion, we will highlight recommendations for developing and implementing an MCI plan for a viral outbreak, such as the current COVID-19 infection. Generally, in the MCI setting, a catastrophic event occurs and multiple victims arrive in a hospital's emergency room within minutes to hours. This is considered the "surge" period, in which hospital resources are rapidly used and possibly overwhelmed by the large number of patient casualties examined within a very short period [11]. Patients are triaged by first responders (paramedics, firefighters, police officers, military personnel) before entering the hospital alongside walking wounded, who arrive by other means. During a viral outbreak, however, there will be a steady increase in patients over a longer period of time, a "protracted surge." This can similarly overburden and inevitably overwhelm a hospital's resources over the span of days, weeks, or even months.

Preparation

The major considerations for a radiology MCI plan for a viral outbreak are to increase throughput of patients that need imaging and protect patients and staff from transmission.

The first step in developing a radiology department MCI plan for a viral outbreak is to build upon your standard radiology MCI plan. Communicate with your hospital's emergency medicine leadership and request the institution's MCI plan, specifically for a viral outbreak. This can be used to help structure the radiology plan around the logistics of the emergency department. Emergency medicine will provide a contact person to discuss all policies and protocols for imaging in the emergency department. Creating an ordering algorithm for specific circumstances will increase overall throughput of essential imaging.

The second step is to contact the infectious disease department to designate a point person to provide instructions for cleaning equipment (portable x-ray machines, ultrasound machines, and CT scanners) and advise specific

precautions to protect hospital staff and patients from transmission. As new guidelines become available, this individual will update your staff.

The third step is to coordinate with environmental services for procedures and time needed for cleaning stationary rooms (CT, MRI, and x-ray). Request air exchange rates for all stationary equipment rooms to help calculate room downtime between examinations.

During the preparation phase, it is also important to update contact information for all staff including pager, home, and mobile telephone numbers for leadership in radiology, emergency medicine, and infectious disease. Policy and procedures may need to change quickly to adapt to immediate needs of patients and direct communication with chairs will help streamline these changes. Section heads are responsible for mobilizing radiologists, and the chief radiologic technologists will be responsible for mobilizing technologists as needed.

Communication within the department of radiology is of critical importance in an ongoing process during an MCI. The radiology leadership, chief technologist, and the MCI plan liaison should communicate at least daily to evaluate the needs of emergency department and inpatient services. Section heads should also communicate at least daily to identify increasing demands and provide additional coverage for services that are being overused.

Mobilization of Resources

Radiologic equipment and personnel are the two main resources in the radiology department. The use of portable equipment is recommended, because it will limit virus transmission by decreasing the number of patients being transported throughout the hospital [12]. Designate a suitable number of portable x-ray units to the emergency department with the ability to increase the number as needed, while still maintaining adequate resources for inpatients. If multiple CT scanners are available and CT imaging is being performed on patients with suspected COVID-19, a dedicated CT scanner is recommended for these patients based on the number of available CT scanners, number of infected versus noninfected patients, and available staff. Stationary equipment should be cleaned based on intuitional policies in concert with the infectious disease department. Imaging throughput will heavily rely on hospital cleaning recommendations for stationary equipment.

Essential radiology department personnel include technologists, ancillary staff, supervisors, and radiologists. Without a true surge, the early stages of a viral outbreak may not necessitate more radiologists; however, more ancillary staff and technologists will be needed because each examination will require more time and effort because of added

Table 1. Imaging chain: from order to communication with questions to provoke discussion

Imaging Chain (CT)	Considerations
Order	Who will order examinations for suspected COVID-19? Is there an algorithm used to determine which patients get a CT scan? Recommend indication or reason for examination to include the term "coronavirus precautions."
Protocol	Will you use a standard chest CT or low-dose chest CT coronavirus protocol?
Scheduling	Who determines the next patient and when imaging is available?
Transport to and from radiology	Is there a dedicated transport team?
Imaging	Image acquisition is based on protocol; see "Adjusting Imaging Protocols" section.
CT scanner cleaning	Determine if facilities management, ancillary staff, or CT technologist will clean the scanner.
Interpretation and communication	Determine communication of findings of COVID-19 cases: written or verbal communication. Consider templates specific for coronavirus.

COVID-19 = coronavirus disease 2019.

precautions, transport, and cleaning equipment. As more infected patients arrive to the hospital, the radiology department may become overwhelmed, especially if chest CT is used for screening. An automated or manual system should be in place to call in extra staff as needed, and the system should be routinely updated with correct contact information [13]. Increasing the number of CT technologists proportionate to the number of available CT scanners will be crucial for decreasing turnaround times and time to diagnosis.

After throughput calculations have been made for a specific institution, an appropriate number of radiologists should be added to limit the bottleneck at the stage of interpretation. Radiology is in a unique position to be able

to provide interpretations from home. Radiologists can be equipped with at-home workstations to decrease the burden of the hospital-based radiologists, especially after hours. As nonessential outpatient imaging is being rescheduled, the volumes will be shifted to inpatient and emergency department examinations.

An MCI plan manager should be designated by the radiology department as the person who will oversee radiology operations during a mass casualty scenario. The radiology department MCI plan manager will decide when radiology resources will be mobilized and the best use of these resources.

Imaging Chain

The imaging chain refers to the process in which a radiologic examination is obtained. Each stage of the imaging chain from the time an order is placed until the imaging findings are communicated should be evaluated. In a viral outbreak, the imaging chain will be most impacted between the transport to and from the radiology department and the cleaning of the scanner. Strategies should be implemented to avoid the potential overuse of radiologic studies [14]. This can be accomplished through use of algorithms for clinical decision making. See Table 1 for imaging chain categories and considerations.

Adjusting Imaging Protocols

It is unclear how large a role CT will play in screening patients for COVID-19 given the recent literature on chest CT versus RT-PCR and the ACR recommendations. Imaging acquisition time is trivial compared with the time to transport the patient, don personal protective equipment, and clean the scanner. If an institution has opted to use chest CT for screening, low-dose chest CT has been shown to be a suitable option for evaluation of pneumonia. Given the added time burden and the potential increase in radiologic examinations in the emergency department and inpatient services, consider adjusting imaging protocols for polytrauma patients and limiting time-intensive studies (ie, gated CT angiography and multiphase imaging).

EDUCATION: MCI PLAN

Education has an important role in decreasing transmission rates and improving patient throughput efficiency. The use of proper precautions can help protect patients and radiology staff. Simulation of MCI plans, including for a viral outbreak, will improve throughput efficiency and find bottlenecks in the imaging chain.

Table 2. Suggested questions to answer during MCI simulation

Questions for MCI Simulation (CT)	Considerations
What is the turnaround time from order to communication?	Provides information on efficiency and throughput
Where does the patient wait to be imaged?	Determines if the radiology department needs a waiting area that meets the CDC recommendations
What is the waiting area capacity?	Determines how many patients can wait in the radiology department
Who determines if a patient can come to radiology and who decides priority?	Radiology nurse, radiology nursing assistant, EM representative
Who transports the patient to and from radiology?	Dedicated versus general transporter, EM staff
Does the radiologist give a "wet read"?	Can decrease time to diagnosis, potentially more errors
Do coronavirus patients have priority over other patients?	Important to have an algorithm in place for patient priority

CDC = Centers for Disease Control and Prevention; EM = emergency medicine; MCI = mass casualty incident.

Recommended Precautions

COVID-19 is highly contagious, and direct contact with blood, sputum, and respiratory droplets carry the greatest risk for transmission [9]. The Centers for Disease Control and Prevention recommends waiting areas for a patient with suspected COVID-19 should include separation by at least 6 feet and recommends standard, contact, and droplet precautions as well as airborne precautions during aerosolizing procedures [15]. Personal protective equipment includes gowns, gloves, masks, and eye protection [16]. Imaging equipment should be cleaned according to manufacturer's instructions and facility policies. Portable imaging is recommended to limit exposure.

MCI Plan Simulation

The use of simulations can identify breakdowns and bottlenecks in the imaging chain [1]. This can also

identify the minimum number of personnel needed from start to finish of the examination. In viral outbreaks, staff may be absent because of illness, so it is important that during these simulations, personnel (ie, x-ray and CT technologists, transporters) should be systematically removed to test how these affect turnaround times and throughput. Although large-scale simulations can be expensive and time-consuming, require a lot of space, and disrupt the day-to-day operations, they have many invaluable benefits. The use of live moulaged actors has the added benefit of offering more realistic encounters [17]. Alternatively, the use of tabletop exercises for MCI can also play a role in MCI simulations. See Table 2 for important questions to answer during an MCI simulation.

In-Service Training

Not all radiology personnel will be available for MCI plan simulations; additional comprehensive in-service training should be given to all staff in the radiology department. The in-service modules should be specific to the role of the personnel. In-service modules specifically designed for radiologists including trainees, technologists (x-ray, CT, ultrasound), ancillary staff, dedicated transporters, and radiology supervisors are recommended. This material should be used as a guide to describe the role and specific expectations for that role. The MCI plan should be available both as a hard copy in an easily accessible location and electronically for all staff to refer to during a crisis. In-service training should also include who to call, how to call, and when to call for additional resources.

CONCLUSION

It is clear that the radiology department will need to be ready for the COVID-19 outbreak. Major factors that will affect radiology throughput are transportation, cleaning equipment, proper usage of personal protective equipment, and interpretation of radiologic examinations. Having an MCI plan in place for a viral outbreak will protect patients and staff and ultimately decrease virus transmission. The use of simulations will help identify throughput and logistical issues. Although screening for COVID-19 with CT is not recommended by the ACR as the prevalence of this disease increases, imaging patients with COVID-19 will increase (ie, polytrauma, stroke, pulmonary embolism, and surgical abdomen). The radiology department should be ready to mobilize equipment and staff to meet the needs of our patients.

TAKE-HOME POINTS

- ACR does *not* recommend CT for screening for COVID-19.

- Use portable imaging equipment for patients suspected of COVID-19.
- Daily intradepartmental and interdepartmental communication is necessary for ongoing policy changes and needs for mobilization of resources.

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