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Radiology Readiness for Monkeypox: Experience From an Epicenter of the Public Health Emergency

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INTRODUCTION

Monkeypox is a viral illness that became a global outbreak in 2022. Monkeypox was declared a public health emergency of international concern by the World Health Organization in July 2022 and a public health emergency in the United States in August 2022. Given the public health threat, it is essential that radiology departments be prepared. This article reviews key information for radiologists and radiology department staff members, including clinical features, the potential role of imaging, possible imaging findings, and suggested procedures for safely obtaining imaging studies in patients diagnosed with or suspected of having monkeypox.

CLINICAL FEATURES

Monkeypox is caused by a virus of the same name (monkeypox virus [MXPV]), a deoxyribonucleic acid virus from the Orthopoxvirus genus, closely related to smallpox, and endemic to areas of West and Central Africa. There are two distinct genetic variants of MPXV: the Congo Basin (Central African) and the West African strains, referred to as clade I and clade II, respectively. Clade II is further divided into two subclades, clades Ia and Ib, with clade Ib being responsible for the 2022 global outbreak [1]. Before the 2022 outbreak, monkeypox had been reported primarily in tropical rainforest areas of Central and West Africa and occasionally exported to other regions through international travel or import of animals infected with monkeypox. In the 2022 global outbreak, cases have been reported worldwide with direct human-to-human transmission. An early report describing cases of monkeypox infection occurring across 16 countries between April 27 through June 24, 2022, reviewed 528 infections, reporting that 98% of individuals with infection were gay or bisexual men, 40% were coinfected with human immunodeficiency virus, and a sexual route of transmission was suspected in 95% of cases [2]. Similar patient demographics have been observed in the United States, with men who have sex with men representing the majority of cases [3].

IMAGING FINDINGS

At this time, the reported imaging findings in monkeypox infection are limited to case series reported in the nonradiology literature and observational studies describing conditions with potential imaging findings [2,4,5]. Before the current outbreak, Sejvar et al [4] described a family cluster with monkeypox infection in 2003, in which one of three infected family members, a 6-year-old girl, developed encephalitis requiring hospitalization. Findings on MRI of the brain included cortical, thalamic, and brain stem edema and meningeal enhancement [4]. The relevance of these imaging findings to cases in the current outbreak remains to be seen. Observational studies from the current outbreak describe several conditions expected to result in significant imaging findings, including proctitis, tonsillitis, abscess, and lymphadenopathy, although imaging...
findings have not been specifically reported in these cases [2,5]. In our preliminary experience, CT of the abdomen and pelvis for the workup of abdominal pain has demonstrated findings of rectal wall thickening with adjacent perirectal fat stranding in cases of proctitis (Fig. 1), and MRI of for workup of superinfection of painful skin lesions has demonstrated T2-hyperintense skin lesions and subcutaneous abscess (Fig. 2).

IMAGING IN PATIENTS WITH SUSPECTED OR CONFIRMED MONKEYPOX

Patients diagnosed with or suspected of having monkeypox may require imaging tests to evaluate conditions associated with infection, including proctitis, tonsillitis, lymphadenopathy, soft tissue abscess, and meningoencephalitis. Intervventional radiologic procedures may be required in cases of abscess drainage, lumbar puncture, and tunneled catheter placement. Radiology departments must develop policies, workflows, and strategies to safely image patients while keeping other patients and staff members safe. Transmission-based safety concerns include prevention of (1) MPXV transmission to other patients present in the same area at the same time, (2) patients undergoing study using the same equipment after MPXV patients, and (3) safety of radiology health care personnel.

Screening Before Imaging

Screening for signs and symptoms of monkeypox infection will occur mostly in the emergency department or clinic when patients first seek medical care. Patients typically present with symptoms of fever, malaise, lymphadenopathy, and rash, as detailed earlier.

Infection Control Precautions

Infection control precautions should be followed immediately when a patient is suspected of having monkeypox (Table 1). Electronic medical record tools should be used for interprofessional communication when special contact-based precautions and follow-up environmental services are required. These include electronic “red flag” alerts to help communicate with other staff members caring for the patient and to ensure that appropriate infection control precautions are taken when a patient moves to and from the radiology department. When a patient with suspected or confirmed monkeypox is transported to the radiology department, the radiology staff members in that area should be notified before transport with verbal communication by the team caring for the patient.
Table 1. Infection control precautions in cases of suspected monkeypox virus infection.

| Infection Control Precaution                  | Details                                                                 |
|-----------------------------------------------|-------------------------------------------------------------------------|
| Place surgical mask on patient                | ▪ Ensure well-fitting mask covering mouth and nose                       |
| Escort patient to private room                | ▪ If in outpatient setting, place an institution-specific isolation precaution sign on the door  
▪ If in the emergency department or inpatient setting, use institution-specific isolation signs |
| Health care personnel: use personal protective equipment when in contact with patient | ▪ N95 mask  
▪ Face shield or goggles  
▪ Gown  
▪ Gloves |
| Institute airborne precautions in certain scenarios | ▪ Patient is at risk for intubation or airway manipulation  
▪ Has an aerosol-generating procedure |

**Room Cleaning**

Upon completion of the imaging test, terminal cleaning of the room and imaging equipment should be performed. All surfaces in contact with the patient should be cleaned and disinfected using an Environmental Protection Agency–registered, hospital-grade disinfectant with emerging viral pathogen claim.

Airborne precautions should be used when a patient with suspected or confirmed monkeypox undergoes an aerosol-generating procedure or airway management or is intubated while in the radiology department. Although MPXV is not a respiratory virus, like severe acute respiratory syndrome coronavirus 2, it is present in saliva and in pharyngeal lesions, leading to a risk for aerosolization [6]. If an aerosol-generating procedure is performed, then the room should not be used until enough time has passed for complete air exchange to take place.

**Radiology Staff Training**

Radiology staff training is essential for the successful implementation of appropriate infection control practices. Routine questionnaire-based screening for monkeypox has not been widely implemented in Radiology Departments at this time, and screening occurs largely in emergency departments or clinics where patients first seek medical care. Nevertheless, it is important for radiology staff members to be aware of signs and symptoms of monkeypox infection so that they may take appropriate action if they are the first to suspect monkeypox infection.

When patients with suspected or confirmed monkeypox infection are transported to the radiology department for imaging, it is essential that staff members be prepared. Radiology staff members should be trained to identify the “red flag” alert marked in the electronic medical record for suspected or confirmed monkeypox infection. Upon receipt of verbal communication informing them of the transport of a patient with suspected or confirmed monkeypox infection to the department, staff members should be trained to immediately communicate the status of the patient to others to ensure the safety of all those who will be in contact with the patient. Arrangements should be made to bring the patient directly into the imaging room upon arrival to limit exposure to other patients and staff members in the waiting areas.

Staff members should be trained on the appropriate personal precautions to take when coming into contact with a patient with suspected or confirmed monkeypox, which include donning an N95 mask, face shield or goggles, gown, and gloves. Staff members should also be familiar with room-cleaning procedures after the completion of imaging. Depending on local practice, this may include training of specific radiology staff members to conduct the terminal cleaning, or it may include alerting environmental services to conduct the appropriate terminal cleaning.

Although patients will often be identified as having suspected or confirmed monkeypox before arriving in the radiology department, some cases may not be suspected at the time the patient presents to radiology. Therefore, adherence to universal infection control precautions is critical to limit the risks posed by unsuspected patients. Staff members should be trained in universal infection control practices, with periodic retraining and refresher courses.

**Workflows in Radiology**

Several workflows unique to radiology practice should be considered by radiology departments when outlining policies and practices for the imaging care of patients with suspected or confirmed monkeypox infection.

**Interventional Versus Non-interventional Studies.** Patients may present to the radiology department for a diagnostic imaging test or an imaging-guided procedure. Interventional and noninterventional studies should be preferentially
performed at the end of the day whenever possible to facilitate room cleaning. Arrangements should be made to make the room available before the patient’s arrival to minimize contact with other patients and staff members in waiting areas. When possible, imaging modalities that minimize physical contact with the patient are preferred. For example, CT or MRI is preferred over ultrasound when clinically appropriate to reduce exposure to sonographers, physicians, and other staff members performing ultrasound.

Several additional factors should be considered in the case of interventional procedures. If a patient must be intubated for a procedure, is at risk for possibly requiring intubation, or is undergoing an aerosol-generating procedure, airborne precautions should be used, and room rest should be performed. The appropriate duration for room rest is dependent on the air-exchange rate in the room and can often be obtained from the hospital engineering or facilities department. Interventional procedures that involve the acquisition of a specimen, such as abscess drainage and imaging-guided lumbar puncture, require careful adherence to local hospital infection control procedures for submitting samples from patients with suspected monkeypox infection, including double bagging of biologic specimens.

**Portable Bedside Imaging.** For patients with suspected or confirmed monkeypox infection, portable bedside imaging is preferable to imaging within the radiology department to reduce the risk for infection transmission during transportation and time in the radiology department. Radiography and ultrasound should be performed portably whenever possible. Technologists should use appropriate personal protective equipment, detailed earlier. Radiographic and ultrasound units should be terminally cleaned upon completion of imaging before transport of equipment.

**Pediatric Imaging.** Children are at low risk for contracting monkeypox, but the infection should be considered in children or adolescents who have a suggestive rash, especially when epidemiologic criteria are present [7,8]. Children and adolescents have been known to contract monkeypox in endemic regions, and at this time a relatively small number of children have contracted monkeypox in the current outbreak [8]. Monkeypox can be transmitted to the fetus in utero and during childbirth.

The approach to imaging children with suspected or confirmed monkeypox infection largely follows the same principles as imaging adults. Neonates whose mothers have monkeypox should be placed in isolation, and appropriate infection control procedures should be followed when caring for them. Young children may not be able to wear a mask, and accommodations must be arranged. Sexually active adolescents may have very similar risk factors to adults with monkeypox infection, and the approach to imaging and infection control is the same as for adults. As with all pediatric imaging, ultrasound or MRI may be preferred over CT when clinically appropriate to limit exposure to ionizing radiation.

It is important to be judicious when considering monkeypox in children and adolescents who are at low risk. Rashes are common in children, and the incidence of monkeypox in this group is currently very low. Nevertheless, as current outbreak of monkeypox disease expands, vigilance remains essential even for low-risk patients.

**CONCLUSIONS**

Monkeypox is a novel and evolving public health threat, and it is essential that radiology departments be prepared. Radiologists should be familiar with clinical features, the role of imaging, imaging findings, procedures for performing imaging studies in patients diagnosed with or suspected of having monkeypox, and an approach to postexposure management.

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