



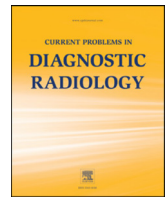
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Current Problems in Diagnostic Radiology

journal homepage: www.cpdjournal.com



Infection Control in Interventional Radiology During the COVID-19 Era

Gabrielle S. Ndakwah^{1,3,*}, Anthony Tucker-Bartley, BS^{1,2,*,#}, Rory L. Cochran, MD, PhD¹, Dania Daye, MD, PhD¹, Robert M. Sheridan¹, Avik Som, MD, PhD¹, Sara Smolinski-Zhao, MD¹, Sanjeeva P. Kalva, MBBS, MD¹, Raul N. Uppot, MD¹

¹ Department of Radiology, Massachusetts General Hospital, Boston MA

² Harvard Medical School, Boston MA

³ Massachusetts Institute of Technology, Cambridge MA

ABSTRACT

The COVID-19 pandemic has challenged the capacity of interventional radiology departments worldwide to effectively treat COVID-19 and non-COVID-19 patients while preventing disease transmission among patients and healthcare workers. In this review, we describe the various data driven infection control measures implemented by the interventional radiology department of a large tertiary care center in the United States including the use and novel re-use of personal protective equipment, COVID-19 testing strategies, modifications in procedural workflows and the leveraging of telehealth visits. Herein, we provide effective triage, procedural, and management algorithms that may guide other interventional radiology departments during the ongoing COVID-19 pandemic and in future infectious disease outbreaks.

© 2021 Elsevier Inc. All rights reserved.

Introduction

Without adequate precautions, interventional radiology staffs are at high risk of infection from COVID-19 and resultant disease complications.¹ Healthcare systems and departmental level infection control guidelines are necessary to protect providers. Lessons learned from previous respiratory virus epidemics can guide current efforts. Many radiology department workflow guidelines implemented in 2003 in response to the severe acute respiratory syndrome (SARS) epidemic may be applicable today.^{2,3} Given SARS-CoV-2 infection appears to have a higher mortality rate, additional adjunctive measures will likely be necessary.⁴

The Society of Interventional Radiology published online guidelines to help interventional radiologists navigate COVID-19 patient care during the pandemic. The purpose of this review is to discuss the practical infection control guidelines for interventional radiology practices based on published data and our experience at a large tertiary medical center, the Massachusetts General Hospital (MGH). These policies can be summarized in 3 major categories – personal protective equipment (PPE) and testing and workflow modifications.

PPE and Testing

Even with recently approved vaccines, the first step in management of COVID-19 is prevention. Prevention can be achieved with

All co-authors contributed to the research, design, writing, or editing of this manuscript.

Conflict of interests: None.

#Reprint requests: Anthony Tucker-Bartley, BS, MD, Harvard Medical School, 260 Longwood Ave, Boston, MA 02115.

E-mail address: anthony_tucker-bartley@hms.harvard.edu (A. Tucker-Bartley).

*First authors contributed equally to this manuscript.

<https://doi.org/10.1067/j.cpradiol.2020.12.011>

0363-0188/© 2021 Elsevier Inc. All rights reserved.

social distancing and wearing masks to minimize airborne spread. In a hospital setting, the most efficient way to minimize transmission is to require all employees wear a mask. Early in the pandemic, our hospital instituted a policy requiring everyone in the hospital to wear a mask at all times and all visitors were prohibited with few exceptions. Additionally, all providers underwent daily symptom checks, via app questionnaire completed by all employees daily, with mandatory 2-week self-quarantine for those who became symptomatic. A recent study demonstrates that universal mask implementation within our health system significantly decreased the rate of SARS-CoV-2 positivity among health care workers.⁵

Furthermore, procedures were stratified to high-risk or low-risk groups based on whether or not the procedures were aerosol generating. For high-risk procedures, including all aerosol-generating procedures (AGPs) as shown in Table 1, we required all personnel apply droplet precautions, which include the wearing of an N95 mask, gown, gloves, and eye protection regardless of the COVID-19 status of patients. This was accompanied by mandatory training for the appropriate donning and doffing of PPE (eg, appropriate fitting, no objects between N95 and the provider's skin, limit use to 1 shift, etc). For low-risk procedures, PPE requirements included gowns, gloves, and surgical masks. To address PPE shortages, extended use of masks and eye protection was allowed and encouraged provided the PPE was not soiled, contaminated, or damaged. Finally, to mitigate N95 scarcity we utilized a mask sterilization plant which enabled safe reuse of N95 masks. This novel approach greatly extended our reservoir of N95 masks while increasing the availability of N95 masks for other healthcare systems.

Procedures were also stratified into emergent or urgent, elective, or case-by-case distinctions and were postponed or performed based on these definitions in order to decrease hospital volume and ensure

Table 1
Procedure components at high risk of aerosol generation, requiring the use of N95 and PPE

<ul style="list-style-type: none"> - General anesthesia (requiring intubation) - Bronchoscopy - Sputum induction - CPR and manual ventilation - Nebulization - High flow nasal cannula - Positive pressure ventilation (CPAP/BiPAP) <p>Enteric access:</p> <ul style="list-style-type: none"> - Orogastric tube - Nasojejunal tube - Gastrostomy tube - Central line placement - Any procedure involving prolonged access via the internal jugular vein

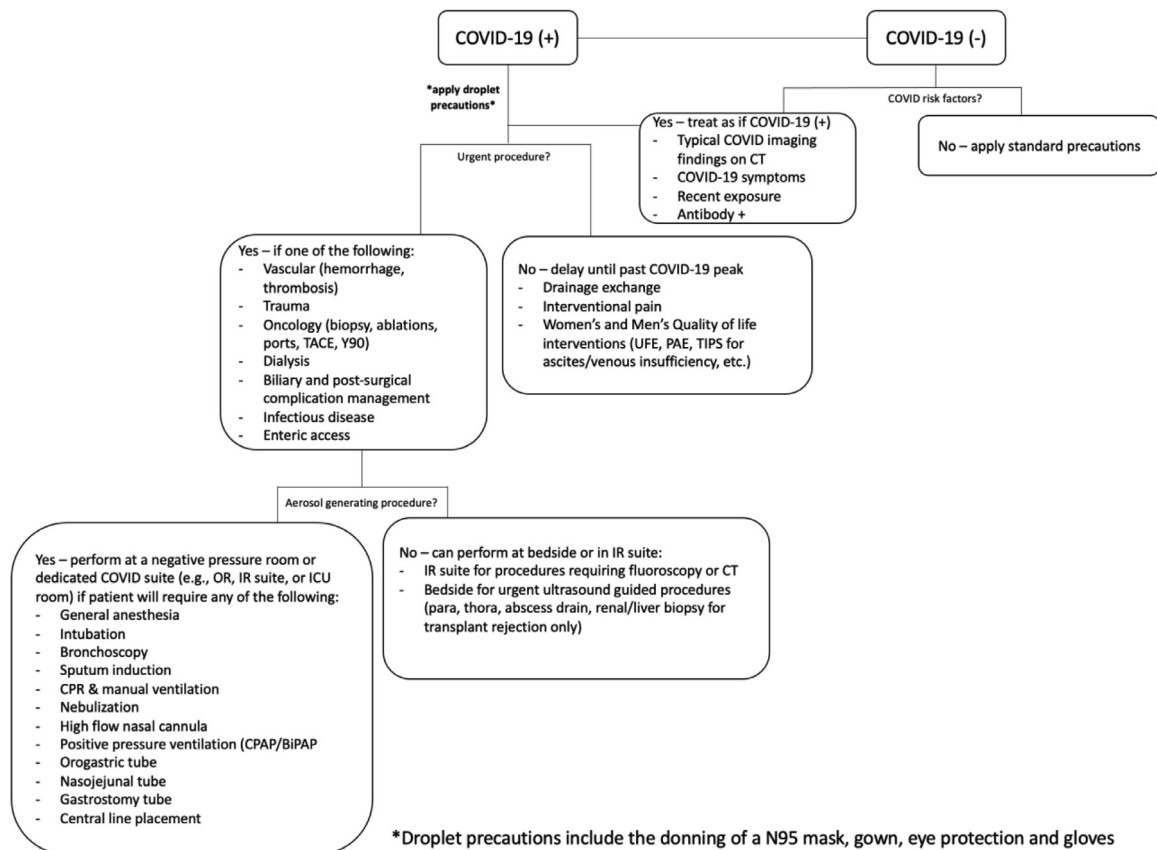
BiPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; CPR, cardiopulmonary resuscitation.

personnel safety.⁶ Delaying a procedure in a COVID-19 infected patient may provide time for the patient to clear the infection and decreases the risk of transmission to health care practitioners. A controversial topic is postponing the care of nonurgent studies or procedures in cancer patients. At our institution, most cancer related care was continued. All patients were tested for COVID-19, and the associated risks for the patient and health practitioners were considered and triaged according to the algorithm in Figure 1. Consult and follow-up visits were maintained by interventional radiology through the use of telehealth visits to enable physicians to interact with patients remotely and further reduce hospital volume.

Workflow Modifications

In addition to the general infection control practices outlined above, our interventional radiology department revised our daily workflow practices based on prior literature. Pua et al suggested that a useful approach for minimizing risk may be to limit the movement of COVID-19 positive patients throughout the hospital by performing more procedures at the patient’s bedside.⁷ To that end we developed an interventional radiology (IR) bedside procedure protocol which outlined the necessary staff, equipment, communication, and steps as shown in Table 2. We performed as many requested procedures on COVID-19 (+) patients as possible at the bedside to minimize patient travel within the hospital. Of note, our IR department saw a significant drop in case volume from week 24 to 40 which corresponds to March 1st to July 1st as shown in Figure 2, which we attribute to COVID-19-related disruptions.

For COVID-19 (+) patients whose procedures were not deferrable, we established a routine ambulatory care for COVID-19 (RACC) space within IR to reduce the risk of infection to non-COVID-19 patients and staff, conserve and manage PPE effectively, and ensure standard processes and workflows are maintained. Small subgroups were formed with specific areas of focus including infection control policies, physical space, PPE, staff education, and patient flow from arrival to departure. Each subgroup was tasked to develop a plan that would safely and effectively support an IR RACC unit. There are 2 IR units at MGH, each unit has 6 procedure suites and multiple imaging modalities to support the practice. After a discussion and a physical tour of the unit with infection control experts, a unit was chosen to help design specific patient workflow that followed strict adherence to the COVID-19 infection control policies at MGH. This unit included



*Droplet precautions include the donning of a N95 mask, gown, eye protection and gloves

Figure 1. Triage algorithm for IR procedures during COVID-19 pandemic. Droplet precautions include donning of N95 masks, gowns, eye protection, and gloves. COVID-19, coronavirus disease 2019 caused by SARS-CoV-2 virus; CPR, cardiopulmonary resuscitation; CT, computed tomography; ICU, intensive care unit; IR, interventional radiology; OR, operating room; PAE, prostate artery embolization; TACE, trans-arterial chemoembolization; TIPS, transjugular intrahepatic portosystemic shunt; Y90, ibritumomab tiuxetan radiotherapy; UFE, uterine fibroid embolization.

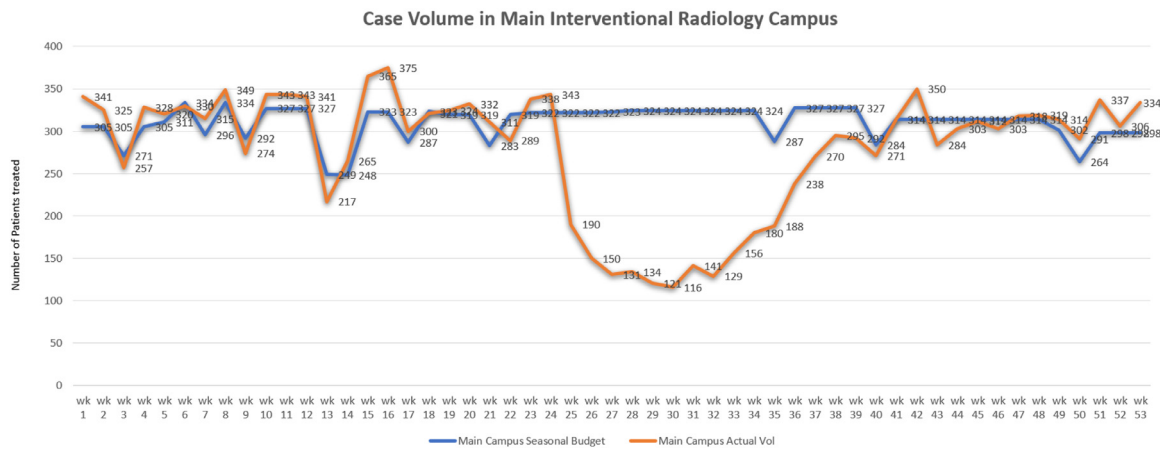


Figure 2. Case volume seen by the main campus IR department. An average fiscal year (blue) and during COVID (orange). Wk 1 corresponds to Sep 1. (Color version of figure is available online.)

Table 2
IR Bedside protocol during COVID-19 Pandemic

<ul style="list-style-type: none"> • Staff: One IR attending, one procedural technologist and one tech as a runner <ul style="list-style-type: none"> ◦ The “runner” will remain outside the room with clean, nongloved hands and is only required to wear a surgical mask per the universal mask policy • Equipment <ul style="list-style-type: none"> ◦ US imaging device ◦ Portable procedural cart ◦ Consumable supplies supporting the procedure ◦ Extra sterile gloves, lidocaine and prep solution ◦ Specimen supplies when applicable • Procedural workflow <ul style="list-style-type: none"> ◦ Bedside briefing initiated by the inpatient primary RN for IR team ◦ Donning PPE equipment for procedures not considered aerosol generating will require: Gowns, gloves, surgical masks and eye protection (MD/APP and Tech), verbal consent (MD/APP). Pre-procedure work-up, note if possible (MD/APP/Trainee), patient prep (MD/APP/Trainee/Tech), sterile tray set-up (Tech), time out (Team) ◦ Expected specimen collection: specimen supplies, labels, confirmation of destination of collected specimen. <i>Specimens must be wiped down and passed out of the room as is done for NP swabbing and all other specimens that are collected in the room</i> ◦ Procedure completed ◦ Sterile tray break-down, sharps management (MD/Tech) ◦ US device cleaning; <i>strict adherence to Infection Control Ultrasound Cleaning Checklist with Sani Cloth AF3 (Gray Top) prior to leaving bedside (Tech)</i> ◦ Doffing of PPE per hospital protocol, hand hygiene with alcohol-based hand rub ◦ Upon return to IR • Tech will upload images to PACS and complete case in EPIC • Complete Epic note and dictation (MD)
--

APP, advanced practice providers; IR, interventional radiology; MD, medical doctor; NP, nasopharyngeal; PPE, personal protective equipment; RN, registered nurse; US, ultrasound. PACS and EPIC are proprietary medical software.

ambulatory care of patients in the following disease areas: Oncology, obstetrics/gynecology, orthopedics, pediatrics, transplant, medical specialties, and surgical specialties. The RACC team was maintained in a consistent location of the IR unit and was staffed with 1–2 IR operators, 2 technologists, and 2 nurses (1 technologist and 1 nurse remained sterile outside of the room for communication and for obtaining additional resources) all of whom were trained in the donning and doffing of PPE. Patients were brought into the RACC unit by a designated clinical staff, standard patient safety checks were performed, and droplet precautions were applied. When intubations and other AGPs were performed, only the involved staffs were allowed inside the procedure room and continuing to at least 30 minutes following the procedure. After the procedure, the patient recovered in the RACC unit and was subsequently escorted to the main hospital exit by a member of the RACC team. The room was disinfected in the

usual fashion after each procedure with the exception of AGPs, which required a 30-minute period of dormancy before room disinfection. This 30-minute duration was set by our hospitals infection control and uses the Facilities Guidelines Institute. Under these guidelines our IR rooms are classified as “procedure rooms” and need to have a minimum of 15 air changes per hour and positive pressure.⁸ In addition, the time required for airborne SARS-COV-2 to decay by 90% is approximately 34 minutes according to the U.S. Department of Homeland Security⁹. For convenience we decided upon 30 minutes. We did not face any significant challenges in implementing this workflow change. This, we believe, was due to the severity of this global universal public health crisis, and the multilateral collaboration with the Procedural Service Commander, the Vice Chair of Procedural Services; the IR Chief of Service, the Director of IR Operation, the Nursing Director, and Infection.

For specific procedures involving vascular or enteric access, the COBRA (COvid Bundled Response for Access) team was established. This multidisciplinary team functioned to assist intensive care units during the pandemic by placing nontunneled central venous access lines, arterial lines, nontunneled dialysis catheters, orogastric, and nasogastric tubes. The team consisted of an attending Anesthesiologist, Interventional Radiologist or Surgeon and PGY3–7 residents. This team allowed for increased efficiency without an increase in complications, given the typical time that would otherwise be required to shut down a procedure room after each procedure performed on a COVID-19 positive patient.

Conclusion

In summary, the COVID-19 pandemic has required major infection control modifications in IR departments worldwide. The potential risk of transmission is high in the procedural setting such as in interventional radiology. Mitigation can be achieved through implementation strategies as outlined above. These strategies may serve as a guide for other large tertiary care centers during the ongoing COVID-19 pandemic and in future infectious disease outbreaks.

Declarations

Ethics approval and consent to participate

1. We certify that ethics approval or consent for participation was not required for this manuscript.

Consent for publication

1. We certify that all authors consented to the publication of this manuscript.

Availability of data and materials

1. All data and materials are freely available

Competing interests

1. There are no competing interests.

Funding

1. Raul N. Uppot reports ACR Innovations Grant, grants from CRICO, outside the submitted work.
2. Sanjeeva Kalva reports personal fees from Medtronic, personal fees from Dova Pharmaceuticals, personal fees from Koo Foundation, Taiwan, personal fees from GE healthcare, personal fees from Springer, personal fees from Elsevier, other from Althea Health Inc, CA, personal fees from Boston Scientific, personal fees from Penumbra, grants from BD, grants from NIH, outside the submitted work.

Author contributions

1. Guarantor of integrity of the entire study
 - a. Raul Uppot
2. Study concepts and design
 - a. Raul Uppot
 - b. Gabrielle Ndakwah
 - c. Anthony Tucker-Bartley
 - d. Rory L. Cochran
 - e. Avik Som
 - f. Dania Daye
3. Literature research
 - a. Gabrielle Ndakwah
 - b. Anthony Tucker-Bartley
4. Clinical studies
 - a. N/A
5. Experimental studies/data analysis
 - a. N/A
6. Statistical analysis
 - a. N/A

7. Manuscript preparation
 - a. Gabrielle Ndakwah
 - b. Anthony Tucker-Bartley
 - c. Rory L. Cochran
 - d. Dania Daye
 - e. Robert Sheridan
 - f. Avik Som
 - g. Sara Smolinski-Zhao
 - h. Sanjeeva Kalva
 - i. Raul Uppot
8. Manuscript editing
 - a. Gabrielle Ndakwah
 - b. Anthony Tucker-Bartley
 - c. Rory L. Cochran
 - d. Dania Daye
 - e. Robert Sheridan
 - f. Avik Som
 - g. Sara Smolinski-Zhao
 - h. Sanjeeva Kalva
 - i. Raul Uppot

Acknowledgments

None

References

1. Remuzzi A, Remuzzi G. COVID-19 and Italy: What next? *Lancet* 2020;395:1225–8.
2. Gogna A, Tay KH, Tan BS. Severe acute respiratory syndrome: 11 years later—A radiology perspective. *AJR Am J Roentgenol* 2014;203:746–8.
3. Lau TN, et al. Is your interventional radiology service ready for SARS?: The Singapore experience. *Cardiovasc Intervent Radiol* 2003;26:421–7.
4. Mahase E. Coronavirus covid-19 has killed more people than SARS and MERS combined, despite lower case fatality rate. *BMJ* 2020;368:m641.
5. Wang X, et al. Association between universal masking in a health care system and SARS-CoV-2 positivity among health care workers. *JAMA* 2020.
6. Cahalane AM, et al. Changes in interventional radiology practice in a tertiary academic center in the United States during the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Radiol* 2020;17:873–7.
7. Pua U, Wong D. What is needed to make interventional radiology ready for COVID-19? Lessons from SARS-CoV epidemic. *Korean J Radiol* 2020;21:629–31.
8. Institute, FG. *The 2018 FGI Guidelines Proposed Revisions to Procedure, Operating, and Imaging Room Requirements*. 2018; Available from: https://www.fgiguideelines.org/wp-content/uploads/2017/11/E94_HCD2017_A_New_Class_Act.pdf.
9. Security, U.S.D.o.H. *Estimated Airborne Decay of SARS-CoV-2 (Virus that causes COVID-19)*. 2020; Available from: <https://www.dhs.gov/science-and-technology/sars-airborne-calculator>.