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Vascular and Interventional Radiology

Role of interventional radiology in the treatment of COVID-19 patients: Early experience from an epicenter

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ABSTRACT

Objective: To highlight the role of interventional radiology (IR) in the treatment of patients hospitalized with coronavirus disease 2019 (COVID-19).

Methods: Retrospective review of hospitalized patients who tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and had one or more IR procedures at a tertiary referral hospital in New York City during a 6-week period in April and May of 2020.

Results: Of the 724 patients admitted with COVID-19, 92 (12.7%) underwent 124 interventional radiology procedures (79.8% in IR suite, 20.2% at bedside). The median age of IR patients was 63 years (range 24–86 years); 39.1% were female; 35.9% in the intensive care unit. The most commonly performed IR procedures were central venous catheter placement (31.5%), inferior vena cava filter placement (9.7%), angiography/embolization (4.8%), gastrostomy tube placement (9.7%), image-guided biopsy (10.5%), abscess drainage (9.7%), and cholecystostomy tube placement (6.5%). Thoracentesis/chest tube placement and nephrostomy tube placement were also performed as well as catheter-directed thrombolysis of massive pulmonary embolism and thrombectomy of deep vein thrombosis. General anesthesia (10.5%), monitored anesthesia care (18.5%), moderate sedation (29.8%), or local anesthetic (41.1%) was utilized. There were 3 (2.4%) minor complications (SIR adverse event class B), 1 (0.8%) major complication (class C), and no procedure-related death. With a median follow-up of 4.3 months, 1.1% of patients remain hospitalized, 16.3% died, and 82.6% were discharged.

Conclusion: Interventional radiology participated in the care of hospitalized COVID-19 patients by performing a wide variety of necessary procedures.

1. Introduction

Coronavirus disease 2019 (COVID-19) is a global pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1]. SARS-CoV-2 enters human cells via the angiotensin-converting enzyme 2 (ACE2) receptors that are found in the lung, heart, kidney, intestine and vascular endothelium [2]. In severe COVID-19, patients may develop respiratory distress, renal failure, cardiac injury as well as venous and arterial thromboembolism [3,4]. Working alongside other medical and surgical specialties, interventional radiology (IR) can play a role in the management of coronavirus-related complications [5–7]. For COVID-19 patients with renal failure, IR physicians may leverage their expertise in image-guided techniques to place hemodialysis catheters even in patients with challenging anatomy due to venous thromboembolism (VTE) [8]. For select patients with VTE, interventional radiologists may place inferior vena cava (IVC) filters as well as perform catheter-directed thrombolysis/thrombectomy for massive or submassive pulmonary embolism and proximal deep vein thrombosis [9–11]. Furthermore, in COVID-19 patients who develop life-threatening bleeding complications while on anticoagulant therapy for VTE, interventional radiologists may perform embolization procedures to treat arterial bleeding. In critically ill coronavirus patients who develop acute cholecystitis and abscesses, IR physicians may place percutaneous cholecystostomy tubes and drainage catheters. For COVID-19 patients who may be suffering from severe dysphagia and malnutrition, percutaneous gastrostomy feeding tubes may be placed in IR with theoretically less aerosolization risk than endoscopic methods.

At the peak of the coronavirus pandemic, limitations in operating
room facilities and ventilators at our hospital shifted the paradigm of care to minimally invasive therapies requiring minimal sedation. As physicians specializing in minimally invasive and image-guided techniques, interventional radiologists are ideally suited to adapting to the COVID-19 environment and delivering safe and effective care to patients. In this study, we describe the utilization of interventional radiology services in coronavirus patients at a tertiary care center in New York City, the epicenter of the COVID-19 pandemic, in April and May of 2020.

2. Materials & methods

In this institutional review board-approved retrospective study, we reviewed patients admitted with COVID-19 who underwent one or more interventional radiology procedures during a 6-week period between April 3, 2020 (first date of increased IR utilization in coronavirus patients) and May 15, 2020 at a tertiary referral hospital in New York City. Increased IR utilization was defined as more than one IR procedure on a COVID-19 patient per day. Clinical outcomes were observed until September 4, 2020, the final date of follow-up. COVID-19 status was confirmed prior to the IR procedure by a reverse-transcriptase–polymerase-chain-reaction (RT-PCR) assay detecting the presence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) RNA in a nasopharyngeal swab specimen. IR procedures were performed by or under the supervision of a board-certified interventional radiologist, and appropriate personal protective equipment was used as per institutional and IR division guidelines. Patient demographic information and clinical data were collected from the electronic medical record system, including: type of IR procedure; location of the IR procedure; type of sedation utilized during IR procedure; complications of the IR procedure; status and length of the hospital stay at the time of last-follow-up. Adverse events were categorized based on the Society of Interventional Radiology (SIR) adverse events classification system.

3. Results

Among the 724 patients hospitalized with confirmed COVID-19, there were 92 (12.7%) patients who underwent a total of 124 interventional radiology procedures. Of these 92 patients, the median age was 63 years (range 24–86 years). Thirty-six (39.1%) patients were female and 56 (60.9%) male. The most common medical comorbidities included hypertension (51.1%), diabetes (27.2%), and chronic kidney disease (17.4%). At the time of the IR procedure, 33 (35.9%) patients were receiving care in the intensive care unit (ICU) and 59 (64.1%) in the medical wards.

The following IR procedures were most commonly performed: placement of central venous catheter (39 [31.5%]), placement of inferior vena cava filter (12 [9.7%]), arterial angiography/embolization (6 [4.8%]), placement of percutaneous gastrostomy feeding tube (12 [9.7%]), image-guided percutaneous biopsy (13 [10.5%]), abscess drainage (12 [9.7%]), and placement of percutaneous cholecystostomy tube (8 [6.5%]) (see Fig. 1). Thoracentesis/chest tube placement (4 [3.2%]) and nephrostomy tube placement (4 [4.2%]) were also performed. Catheter-directed thrombolysis of massive pulmonary embolism was performed in one patient, and thrombectomy of extensive proximal deep vein thrombosis was performed in another patient. Additional procedures (14 [11.3%]) included removal of tunneled central venous catheters, arteriovenous (AV) fistula declot, placement of an external-internal biliary drain, removal of internal ureteral stent from a transplant kidney, paracentesis, port placement, and tunneled peritoneal catheter placement.

Interventional radiology procedures were performed utilizing general anesthesia in 13 (10.5%) patients, monitored anesthesia care in 23 (18.5%), moderate sedation in 37 (29.8%), or local anesthetic only in 51 (41.1%). Moderate sedation was given by the interventional radiologist with monitoring of the patient’s level of consciousness and physiological status during the procedure. Ninety-nine (79.8%) procedures were performed in the IR suite and 25 (20.2%) were performed at bedside. Bedside procedures included placement of cholecystostomy tube, placement of non-tunneled central venous catheter, removal of tunneled central line, biopsy, paracentesis, and drainage of abscess.

The median follow-up from the time of the IR procedure was 4.3 months. There were three (2.4%) minor complications (SIR adverse event class B); in all three cases, there was superficial bleeding requiring only nominal therapy (i.e., manual compression). One (0.8%) major complication (class C) occurred; a tunneled central venous catheter placement was complicated by bleeding that resulted in the withholding of anticoagulation. There were no deaths attributable to interventional radiology procedures. At the time of this review, 15 (16.3%) of patients had died, 1 (1.1%) remain hospitalized and 76 (82.6%) had been discharged.

Fig. 1. Interventional radiology procedures in hospitalized COVID-19 patients.
*Other = PE thrombolysis, DVT thrombectomy, arteriovenous (AV) fistula declotting, biliary drain placement, removal of renal transplant internal ureteral stent, paracentesis, tunneled line removal, port placement, peritoneal catheter placement.
discharged from the hospital. The mean length of hospitalization was 1.4 months (range 0.1–4.7 months).

4. Discussion

During a 6-week period at the height of the coronavirus pandemic, 92 of 724 COVID-19 in-patients underwent 124 interventional radiology procedures at our institution. The most commonly performed IR procedures were placement of central venous catheters, inferior vena cava filters, gastrostomy tubes, cholecystostomy tubes as well as image-guided biopsy and abscess drainage. 20% of IR procedures were performed at the bedside by relying on portable ultrasound imaging equipment. More than 70% of IR procedures were performed with local anesthetic or moderate sedation, not requiring the support of an anesthesiologist. At the time of the IR procedure, approximately one-third of patients were receiving care in the intensive care unit. Mean length of hospitalization was 1.4 months. Overall complications rates were low, and no deaths were attributable to IR procedures.

Interventional radiology procedures have contributed to the care of COVID-19 patients worldwide. Reports from Europe, Asia, and North America outline the safety precautions utilized during the COVID-19 pandemic in performing IR procedures [7,12-14]. In the largest study of IR procedures during the COVID-19 pandemic, 550 patients underwent 671 procedures at a tertiary care hospital in Italy [12]; this study found that there were no incidents of cross-infection and no reports of COVID-19 infection of healthcare workers in the IR service. However, in this Italian study, only nine (1.34%) patients were classified as “suspected” and only one patient (0.15%) was confirmed positive for SARS-CoV-2. In contrast, all patients in our study had confirmed SARS-CoV-2 by RT-PCR testing. In treating COVID-19 patients, infectious prevention strategies were instituted including altering the workflow to minimize contact time, using adequate PPE, following proper wait times as well as following strict cleaning protocols between cases [15]. Bedside procedures were utilized as much as possible to minimize transport of patients and to preserve PPE. Compared to surgeries in the operating room, interventional radiology procedures may potentially require less PPE and less support staff [16,17].

COVID-19 may target the pulmonary, cardiovascular, renal, hepatic, gastrointestinal, and neurologic systems [18-22]. The resultant multi-organ dysfunction associated with COVID-19 necessitates a multidisciplinary approach to treatment, with interventional radiology contributing to the care of many patients (see Table 1). In severe COVID-19, venous thromboembolism appears to be common, with early studies showing VTE in 36% of patients and acute pulmonary embolism (PE) in 30% of patients who underwent imaging tests [23-25]. However, the management of VTE is challenging due to the complex relationship between coagulation abnormalities and antithrombotic therapy in COVID-19 patients [9,10]. In particular, the role of inferior vena cava (IVC) filters in coronavirus patients is not entirely clear. At our institution, indications for filter placement in COVID-19 patients were DVT/PE, deep vein thrombosis (DVT), acute limb ischemia, and no deaths were attributable to IR procedures.

Table 1
COVID-19 complications, interventional radiology procedures and potential clinical benefits.

| COVID-19 complication | Interventional radiology procedure | Potential clinical benefit |
|----------------------|-----------------------------------|---------------------------|
| Renal disease        | Central venous catheter placement | Perform hemodialysis       |
|                      | Peritoneal catheter placement     | Perform peritoneal dialysis|
|                      | Nephrostomy tube placement        | Relieve urinary obstruction|
|                      | Renal biopsy                      | Guide treatment of renal disease|
| Thromboembolic disease - acute pulmonary embolism (PE), deep vein thrombosis (DVT), acute limb ischemia | IVC filter placement | Potentially prevent life-threatening PE in patients unable to be anticoagulated |
| Bleeding (secondary to anticoagulant therapy) | Angiography with embolization | Treat life-threatening arterial bleeding |
| Dysphagia/malnutrition | Gastrostomy feeding tube placement | May be performed with less sedation and less aerosolization than endoscopic approach |
| Pleural effusion/ascites | Chest tube placement, thoracentesis, paracentesis | Improve oxygenation and provide symptomatic relief |
| Abscess              | Percutaneous drainage             | Drain purulent fluid to resolve infection |
| Cholecystitis        | Cholecystostomy tube placement    | Treat inflammation and infection of gallbladder |

physicians can also place peritoneal dialysis catheters as well as provide maintenance of arteriovenous access site (fistula and graft management).

COVID-19 has a wide spectrum of clinical manifestations ranging from asymptomatic patients to severely and critically ill patients that require treatment in the intensive care unit. Patients with serious coronavirus-related complications may need image-guided procedures by an IR physician as part of their hospital course. IR has several advantages during the COVID-19 pandemic: procedures may be performed at the bedside, which minimizes viral exposure; majority of procedures do not require general anesthesia, which obviates the need for aerosol-generating intubation; and IR therapies are associated with low morbidity and very low mortality. In the context of the highly contagious novel coronavirus, infection control measures are critical during IR procedures in COVID-19 patients. Currently, there is still a large knowledge gap in the exact transmission rate of coronavirus associated with IR procedures. Additional studies are needed to determine the risk of viral spread during aerosol-generating IR procedures as well as to further refine infection prevention and control strategies.

This study has several limitations. First, our study cohort only included patients at a single tertiary referral center. Second, this study was retrospective in nature and the median follow-up was only 4.3 months. Third, image-guided procedures performed at the bedside by radiologists redeployed to the medical wards or ICU were not documented as interventional radiology procedures; this may have underestimated the true utilization of image-guided interventions by radiologists.

5. Conclusion

Our early experience shows how interventional radiology participated in the care of hospitalized COVID-19 patients at a tertiary care center in New York City during the height of the coronavirus pandemic.
Interventional radiologists used image-guided procedures to treat coronavirus complications in the lung, kidney, intestine, gallbladder and vasculature. Future investigations may evaluate the true benefit of the minimally invasive nature of IR procedures in COVID-19 patients and their reduced risk of viral transmission compared to surgery.

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Ethical approval
This retrospective study was approved by the Institutional Review Board (IRB). For this type of study, formal consent is not required.

Informed consent
This study has obtained IRB approval from the Weill Cornell Medicine IRB committee and the need for informed consent was waived.

Consent for publication
For this type of study, consent for publication is not required.

Declaration of competing interest
Dr. Lee received honorarium from Embolx, Inc., outside of submitted work. The other authors (Dr. Talenfeld, Dr. Browne, Dr. Holzwarnger, Dr. Harnain, Dr. Kesselman, Dr. Pua) declare that they have no conflict of interest.

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