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.

Diagnostic angiography showed the bleeding site in all cases (lumbar/ileolumbar [8/15; 53.3%], inferior epigastric [2/15; 13.3%], inferior gluteal [1/15; 6.7%], lateral circumflex femoral [1/15; 6.7%], sigmoidal [1/15; 6.7%] right bronchial [1/15; 6.7%], and internal thoracic artery [1/15; 6.7%]). The typical angiographic pattern (found in 12 of 15 patients; 80%) consisted of multiple, tiny bleeding foci affecting distal vascular territories (**Fig a–d**). Considering this peculiar bleeding pattern and the critical condition of most patients, embolization with polyvinyl alcohol particles of the entire arterial segment accounting for the hemorrhage was usually performed. Technical and complete clinical success was achieved in all patients; no procedure-related complications were recorded (1).

The origin of severe hemorrhage in patients with COVID-19 is unclear. Prophylactic antithrombotic treatment has been established as a well-known risk factor; however, the reported incidence of major spontaneous hemorrhage in general admission patients receiving low-molecular-weight heparin at prophylactic dosage is $< 1\%$ (2), below the disease-specific incidence observed in the present population (1.8%). A possible explanation could lie in the pathophysiology of SARS-CoV-2 infection, which is characterized by an increase of proinflammatory cytokines in serum (systemic cytokine storm), directly correlated with both disease severity and subtle coagulation disorders. Furthermore, widespread endothelial cell damage has been hypothesized to occur (3). Functional implications of this pathogenic mechanism include diffuse microvascular damage with both a substantial component of microvascular thrombosis [microCLOTS hypothesis (3)] and imbalances in platelet recruitment. The latter could then result in multiple bleeding foci typically affecting distal microcirculation, as suggested by observations in the present population and confirmed by pathologic findings (4), and occurring late in the disease course (median time to bleeding onset 23 d).

In conclusion, major spontaneous hemorrhage represents a quite uncommon, but dramatic complication of SARS-CoV-2 infection, possibly representing the other, less noted side of disease-specific coagulation disorders. Failure to acknowledge such a risk could significantly worsen the prognosis of patients with COVID-19.

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Transforming Positive Pressure IR Suites to Treat COVID-19 Patients

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Editor:

During the coronavirus disease 2019 (COVID-19) pandemic, the role of interventional radiology (IR) became integral secondary to the minimally invasive nature of treatments, the efficiency of image-guided techniques, and the nominal reliance on inpatient hospital resources. IR divisions are forced to adapt to care for a growing population of patients with coronavirus while maintaining a safe work environment and preventing cross-infection. As most procedural suites with fluoroscopic capability are positive-pressure rooms, here the authors describe an experience with a positive-pressure IR suite to create a safe, optimized environment for health care workers and patients. No institutional review board approval was required, as human and animal subjects were not involved.

Procedure suites were chosen based on maximal potential air exchange, most direct patient transit path, and space for donning and doffing of personal protective equipment (PPE). Designated procedure suites were cleared of all nonessential mobile equipment, and the remaining equipment was covered in plastic to allow easy disinfection between patients. In consultation with hospital infection prevention and control personnel, the largest and most secluded IR suite was chosen for the treatment of patients with COVID-19 (**Fig 1**). If present, a small

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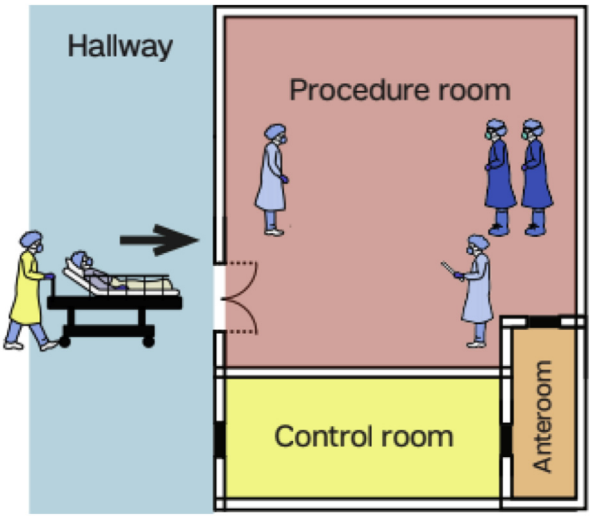

Figure 1. Diagram of IR positive-pressure suite with small passageway, anteroom, connecting procedure room, and control room.

Figure 2. A hallway connecting the procedure room and control room was converted into an anteroom through the use of floor-to-ceiling plastic barriers with zippers.

passageway connecting the procedure room and control room can be converted into an anteroom with the use of 2 plastic barriers secured to the ceiling and floor (Fig 2). These barriers have zippers that allow 1 individual to safely enter and exit the space at a time.

Aside from the traditional IR suite, there are several other possible settings in which to perform interventional procedures. IR procedures can also be performed in the operating room suite, with or without an attached control room, which carries the advantage of superior exchange. Some procedures can be performed at bedside, with or without an anteroom. Bedside procedures minimize COVID-19 exposure to hospital staff and patients by eliminating the need to transport patients. A standardized case-by-case approach was implemented for each inpatient consultation to decide the safest and most efficient procedural location (Table).

To adhere to social distancing recommendations from the Centers for Disease Control and Prevention, inpatients were transported directly into their assigned procedure room, and, when the procedure and recovery was complete, back to their hospital room.

All outpatients were screened by a faculty member for medical necessity, and nonurgent cases were postponed accordingly. Cases deemed medically necessary were screened for symptoms via telephone by IR scheduling staff. Nonurgent symptomatic patients (fever, cough, recent travel, positive COVID-19 test, or recent close exposure) were delayed/postponed. For those patients whose cases could not be postponed, a protocol was crafted in which the patient would be immediately escorted to their procedure room on arrival, bypassing the front desk and the holding bay. From registration to recovery, a COVID-19–positive outpatient or person under investigation (PUI) remained in the procedure room. Depending upon availability of COVID-19 testing, different workflows could ultimately be established. With rapid same-day testing, COVID-19–confirmed and PUI patients can be scheduled in the modified IR suite while nonmodified IR suites can be designated for COVID-19–negative patients or as backup holding rooms for overflow COVID-19–positive patients on the floor.

The traditional consent process was also modified to minimize interaction with patients with COVID-19 or PUI patients. Consent was obtained in the procedure room with the provider wearing appropriate PPE (as described in recent literature) or via oral consent documented by the physician in the electronic medical record (1).

When the facilities have been established, specific protocols and designated roles for each member of the procedure team were clearly delineated and simulated. Staff completed a required series of donning and doffing videos and attended question-and-answer sessions with members of the infection control team.

During the early weeks of the crisis, a designated "observer" within the department monitored the workflow of each procedure team and identified potential steps to streamline. Detailed donning and doffing sequences for each essential IR team member were created to keep individuals safe and hold each other accountable, including specific roles for "scrub" and "circulating" nurses and technologists. Each team also had a designated "clean" runner who stayed outside the immediate procedure suite to obtain additional equipment, receive specimens, and call for aid if necessary.

Another critical component is to determine the appropriate wait times and cleaning protocols between cases. Although COVID-19 is primarily spread by respiratory droplets, the exact amount of time for aeration of a room that has been occupied by a COVID-19–positive patient is

Table. Advantages and Disadvantages of Performing IR Procedures on COVID-19 Patients in Different Procedural Locations

Site	Practitioner Point of View		Patient Point of View	
	Advantages	Disadvantages	Advantages	Disadvantages
IR suite	• Familiar environment and machinery • Easy accessibility to additional supplies and equipment • Can be scheduled without additional coordination as we control IR schedule	• Inferior air exchange rate • Only one suite has been modified; could encounter delays if other suites are unavailable	• Can be scheduled without additional coordination, as we control IR schedule	• Only one suite has been modified; could encounter delays if other suites are unavailable
OR suite	• Superior air-exchange rate • Less exposure to other staff members on the floor (ie, those not involved in case)	• Could encounter delays if the OR is not immediately available • C-arm and OR table have limited functions vs angiographic fluoroscopic machine	–	• Could encounter delays if the OR is not immediately available • Anesthesia needs to be involved for all cases
Bedside	• Minimize potential exposure to hospital staff members • Minimize potential exposure to other patients as intrahospital transport is not needed • Frees up room time in IR department	• Takes additional time and effort to coordinate mobile equipment availability • Room setup and patient positioning is usually less than ideal • Additional supplies and equipment not easily available • Higher risk of technical failure and need for imaging beyond US	• More comfortable: no need for transfer onto stretcher, no need for transport	• Possibility of requiring second procedure if bedside procedure unsuccessful

COVID-19 = coronavirus disease 2019; OR = operating room.

unknown, but likely depends on multiple factors, including air circulation and procedure type (2,3). In the authors' institution, the 45-minute wait time was based on air-exchange rates in the modified procedure room, and will vary depending on room size and layout (Fig 3).

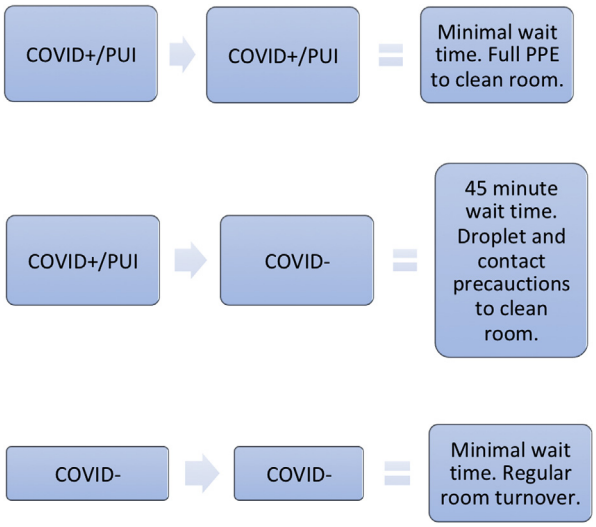

Figure 3. Proposed wait time and room turnover policy between consecutive patients during the COVID-19 pandemic.

In conclusion, strategies can be adopted in a traditional IR practice to safely and successfully perform procedures on patients with COVID-19, including but not limited to optimizing inpatient and outpatient workflow to minimize contact time and transit time, using appropriate PPE for essential staff, and following appropriate wait times and cleaning protocols between cases. These low-cost alterations require no permanent structural changes and can transform an existing positive-pressure IR suite into a safe environment for patients and health care workers.

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Direct, Percutaneous, Cervical Thoracic Duct Access under Ultrasound Guidance

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Editor:

Direct, retrograde thoracic duct access is a technique that may improve the clinical success of thoracic duct embolization if the transabdominal approach is unsuccessful and may potentially obviate the need for intranodal lymphangiography with oil-based contrast agent. Minimally invasive thoracic duct interventions have become the standard of care in many institutions for chyle leaks, and future interventions may treat conditions ranging from autoimmune diseases to heart failure (1). The most common technique to access the thoracic duct is the transabdominal approach, where the cisterna chyli is cannulated in the midabdomen after opacification by lymphangiography. This approach is technically challenging. Multiple factors impact successful transabdominal cannulation, including visualization of the cisterna chyli, patient body habitus, and patient anatomy; first-attempt technical success rates of 62%, 67%, and 74% are reported in the literature (2–4). Alternative techniques to access the thoracic duct include transvenous retrograde access and direct thoracic duct puncture near the venous angle. The purpose of this letter is to document the steps to perform percutaneous, direct cannulation of the thoracic duct at the base of the neck under ultrasound guidance. Institutional review board approval was deemed unnecessary for this technical note.

Before thoracic duct access, non–contrast-enhanced computed tomography of the chest is reviewed to identify the side of the thoracic duct insertion site, which is most often found at the left venous angle near the junction of the internal jugular vein and the subclavian vein. The duct is more easily identified in adults compared with children owing to increased adipose tissue surrounding the duct that aids in identification. Dynamic contrast magnetic resonance lymphangiography has recently emerged as an imaging modality to visualize the central lymphatic anatomy (5) and may improve the technical success rate, as normal variants in central lymphatic anatomy are common (6).

A linear, 5- to 10-MHz ultrasound transducer is used to visualize the structures at the base of the left neck (**Figs 1a, b** and **2a, b**). One study reported visualization of the thoracic duct in 96% of adult examinations (7). When the ultrasound probe is oriented parallel and slightly lateral to the internal jugular vein, the thoracic duct is typically located posterolateral to the internal jugular vein and anterior to the vertebral vein. In short-axis view, with the probe oriented parallel to the clavicle, the thoracic duct can often be seen at the confluence of the internal jugular vein and the subclavian vein (**Video 1** [available online on the article's Supplemental Material page at *www.jvir.org*]). The insertion site is often confirmed by identifying the thoracic duct terminal valve and the flow of echogenic chyle into the venous angle.

Under direct ultrasound guidance, a 21-gauge echogenic micropuncture needle (Cook, Inc, Bloomington, Indiana) is used to access the thoracic duct. The best access approach allows the wire to be advanced in a straight orientation and avoids sharp angles (**Fig 3a, b**). Correct needle positioning is confirmed by ultrasound visualization and injecting of a mixture of 50% normal saline with 50% Omnipaque contrast agent (GE Healthcare, Chicago, Illinois) to opacify the lymphatic system. Chylous return is neither typical nor necessary to confirm correct positioning (**Video 2** [available online on the article's Supplemental Material page at *www.jvir.org*]), and the color of chyle varies significantly with the patient's diet. An 0.018-inch guide wire is then advanced through the needle into the thoracic duct. Preferred wires include palladium- or platinum-tip micropuncture set wires or Nitrex wires (Medtronic, Minneapolis, Minnesota). Hydrophilic wires may be used with the risk of the coating sheering off. The needle is removed and a 3-F dilator is advanced over the wire. The 3-F dilator allows contrast injection to delineate anatomy and subsequent placement of a guide wire to maneuver beyond the valves to the area of interest. Wire manipulation should be gentle to avoid transection or perforation; if the wire does not travel as expected, contrast agent should be injected to investigate the thoracic duct anatomy and identify variants or occlusions. When there is sufficient guide wire purchase to provide stability, a 5-F radial sheath (Terumo Corp, Tokyo, Japan) can be placed to permit catheter exchanges or even side-by-side catheter placement. Once stable access to the target region (eg, cisterna chyli, mesenteric lymphatics, intrathoracic lymphatics) is achieved, diagnostic imaging and/or interventions are performed.

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Videos 1 and 2 can be found by accessing the online version of this article on *www.jvir.org* and clicking on the Supplemental Material tab.

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