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Vascular and Interventional Radiology

Interventional radiology procedural volume changes during COVID-19 initial phase: A tertiary level Midwest health system experience

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ABSTRACT

Background: To evaluate Interventional Radiology (IR) procedural volume changes at a large Midwest health system between March 17, 2020 and April 30, 2020 following a state-mandated shutdown of nonessential procedures during the initial phase of COVID-19.

Methods: IR procedural volumes were compiled, stratified by location and compared with Diagnostic Radiology (DR) volumes during the same timeframe. Procedure volume was categorized by type, including oncology, dialysis interventions, and drainage procedures with comparisons made using Z-score test for proportions. IR and system-wide surgical procedural volume was compared with baseline values.

Results: System-wide IR procedural volume decreased by 35%, with a 41% decrease in outpatient and a 25% decrease in inpatient volume during the state-mandated order. DR volume decreased by 45%, with a 57% decrease in outpatient and a 22% decrease in inpatient volume. Total IR procedural volume during the mandate was 1077 versus 1518 during the preceding six weeks. The proportion of Interventional Oncology and dialysis interventions showed no significant change ($p > 0.05$) while that of drainage procedures increased ($p < 0.05$). Compared to baseline values, system-wide procedural volumes for IR, Vascular Surgery, Urology, General Surgery, Gastroenterology and Gynecology decreased by 3%, 11%, 25%, 20%, 38% and 31% in March 2020 and 25%, 47%, 68%, 63%, 79% and 73% in April 2020 respectively.

Conclusion: Outpatient IR volumes were less impacted compared to DR during the initial phase of COVID-19. Oncology, dialysis and drainage interventions may be considered essential procedures due to their stability. IR volumes were less affected compared to other procedural specialties.

1. Introduction

Coronavirus disease 2019 (COVID-19) has had a catastrophic impact on global health and has placed a high demand on health care resources nationwide. Among the states most impacted is New York, where over 1000 deaths were reported within a month from the first diagnosed case.¹ Ohio, among the states less impacted, crossed the same threshold nearly three months following its index case.² During the initial surge phase in March 2020, state and federal policies were implemented to slow the spread of COVID-19 and conserve resources. These policies included a mandate for health systems to halt all elective and non-essential surgeries and procedures.^{3,4} In Ohio, these restrictions were in effect between March 17, 2020 and April 30, 2020. As expected, revenue significantly diminished for almost all hospital departments,

including both Diagnostic Radiology (DR) and Interventional Radiology (IR). Recent published data from large health systems in New York and Massachusetts showed significant decline in DR and IR volumes.^{5,6} The IR departments actually reallocated many of their own resources towards supporting critical care and other overwhelmed services.

The relative changes in IR case volumes compared to DR and other subspecialties during a pandemic like COVID-19 has not been previously studied. However, quantifying and comparing these changes can guide the operational strategy of a healthcare system in crisis. The purpose of this study was to evaluate the impact of the COVID-19 pandemic on the IR section of a large healthcare system in Ohio and comparing this impact to that of DR and other subspecialties, with detailed stratification and characterization of the IR procedures performed.

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2. Materials & methods

2.1. IR procedural volume data collection and analysis

Institutional Review Board waiver approval was obtained for this study. A retrospective analysis was performed at a single hospital system comprised of a tertiary referral academic medical center and multiple community hospitals. The four highest volume community hospitals with full-time IR services were included in this analysis. Data was obtained from M*Modal Scout, a business intelligence and analytics platform that aggregates data primarily from the Radiology Information System (RIS) and Picture Archiving and Communication System (PACS) to construct performance statistics by analyzing all radiologist-generated reports (3 M M*Modal Scout, Pittsburgh, PA, USA). This tool was utilized to gather Diagnostic and IR volume data between January 2020 and April 2020. This period included the state-mandated shutdown of non-essential procedures from March 17th to April 30th.

The list of IR accession numbers was then evaluated. Duplicate entries were subsequently excluded using final time stamps to consistently display one accession number per procedure. The IR Procedures were selected from the dataset by using filters that accounted for Attending Name and Exam Description. For the purpose of this data analysis, only Ultrasound, CT and Fluoroscopic guided procedures were included in the total IR volumes. Vascular and non-vascular diagnostic radiology codes and all clinic consult codes were excluded to focus on procedural volumes only.

Procedures were then ordered chronologically and seven-day rolling aggregates were measured and recorded to account for the inherent daily variance. IR volumes were further stratified into groups based on location: All Sites, Main Campus and Community. The data was also stratified into outpatient and inpatient groups. IR volumes were then plotted against time. Evaluation of percentage change in IR procedural volumes was calculated in comparison to baseline IR volume. The baseline volume was defined by calculating the weekly averages of seven-day rolling aggregated values prior to the state mandated shutdown of nonessential procedures (between January 1, 2020 and March 17, 2020).

2.2. Comparison of IR versus diagnostic radiology volumes

System-wide completed exams were obtained for all radiology using M*Modal Scout in a similar manner as described above. Accession numbers were ordered chronologically and stratified into inpatient and outpatient groups. Subsequently seven-day rolling aggregates were calculated to reduce the inherent daily variance. The previously obtained IR accession numbers were then subtracted from the assembled seven-day rolling aggregates to define DR case volume. The collected data was compared to seven-day rolling aggregates for IR during this time. Average weekly data from January 1st to March 17th (prior to the government mandated shutdown) was compiled for both Diagnostic and Interventional Radiology and used as baseline volumes respectively. Weekly averages were then compiled for Diagnostic and Interventional Radiology from March 18th to April 30th. The weekly difference from pre-shutdown average values was then calculated and graphed as percentage change.

2.3. Comparison of procedural volumes between IR and other surgical specialties

Surgical volume data at our institute is recorded in a continually updated centralized database. The data is organized on Microsoft Excel and reports are created and regularly distributed to all involved parties. Surgical volumes are reported on a monthly basis. Total monthly volumes for five different surgical specialties including Vascular Surgery, Urology, General Surgery, Gastroenterology and Gynecology were obtained for January 2019 to April 2019 and January 2020 to April 2020.

To evaluate the effect of the COVID-19 pandemic, March and April 2020 volumes were compared with baseline monthly volumes. In this case, baseline monthly volume was calculated as an average of six months (January–April 2019 and January–February 2020). The purpose of including January to April 2019 was to account for any inherent seasonal variability in the months preceding the pandemic. Percent change in volume for each specialty was calculated and plotted.

2.4. Comparison of IR procedure type during Governor's order and the 6 preceding weeks

The Governor's order to postpone all elective and non-essential procedures came into effect on March 17 and lasted until April 30, 2020. Total number of IR procedures performed during this period and the six weeks preceding this period (February 4, 2020 – March 16, 2020) were recorded. The procedures were further categorized based on type and admission status (inpatient versus outpatient) and compared between the two time periods.

Procedures were stratified into categories including interventional oncology, dialysis interventions, aspiration/drainage procedures and additional miscellaneous procedures. Pertinent oncology procedures included biopsies, local-regional therapy including radioembolization, percutaneous ablation, and mediport placement for initiation of systemic therapy. Pertinent dialysis interventions included temporary dialysis catheter placement, tunneled catheter placement, and access site interventions including thrombolysis and angioplasty. Pertinent aspiration and drainage procedures included thoracentesis, paracentesis, percutaneous cholecystostomy, biliary drainage and nephrostomy tube placement. A Z-test for proportions was utilized to compare the proportion of cases in the different categories during the two time periods using Microsoft Excel Analysis ToolPak.

3. Results

The average seven-day rolling aggregate prior to March 17, 2020 (Governor's order to postpone elective and non-essential procedures) and between March 17, 2020 and April 20, 2020 was 252.0 and 163.8, respectively, for the entire hospital system. This comprised a 35% decrease in IR procedural volume. Evaluation of the seven-day aggregate values in relation to Governor's mandated shutdown is depicted in Fig. 1. Additionally, volume stratified by location is graphically delineated in Fig. 2, with more precipitous decline noted at community IR sites. The average seven-day rolling average for outpatient and inpatient procedures was 154.8 and 97.6, respectively, before March 17, 2020. These average figures were 91.2 and 72.8 during the Governor's order, which ultimately represented a 41% decrease in outpatient procedure volume and 25% decrease in inpatient procedure volume. Evaluation of the IR procedural volume by service location is depicted in Fig. 3.

Compared to IR volume, total DR volume decreased by 45% between March 17th and April 30th. Outpatient DR volume decreased by 57% and inpatient DR volume decreased by 22%. Graphical analysis of aggregate volume per week stratified by service location following the shutdown is delineated in Fig. 4. In comparison to IR, DR experienced and more continuous and sustained decrease in volume.

IR volume for the entire hospital system for the month of March and April 2020 decreased by 3% and 25% respectively when compared with the baseline defined as the average 6-month volume between January–April 2019 and January–February 2020. Vascular Surgery, Urology, General Surgery, Gastroenterology and Gynecology surgical/procedural volumes decreased by 11%, 25%, 20%, 38% and 31% for March 2020 respectively and decreased by 47%, 68%, 63.3%, 79% and 73% for April 2020 respectively as outlined in Fig. 5.

A total of 1518 IR procedures were done between February 4th and March 16th. Of these, 930 (61%) were outpatient and 588 (39%) were inpatient. Compared to this period, the total number of IR procedures done between March 17th and April 30th were 1077. Of these, 594

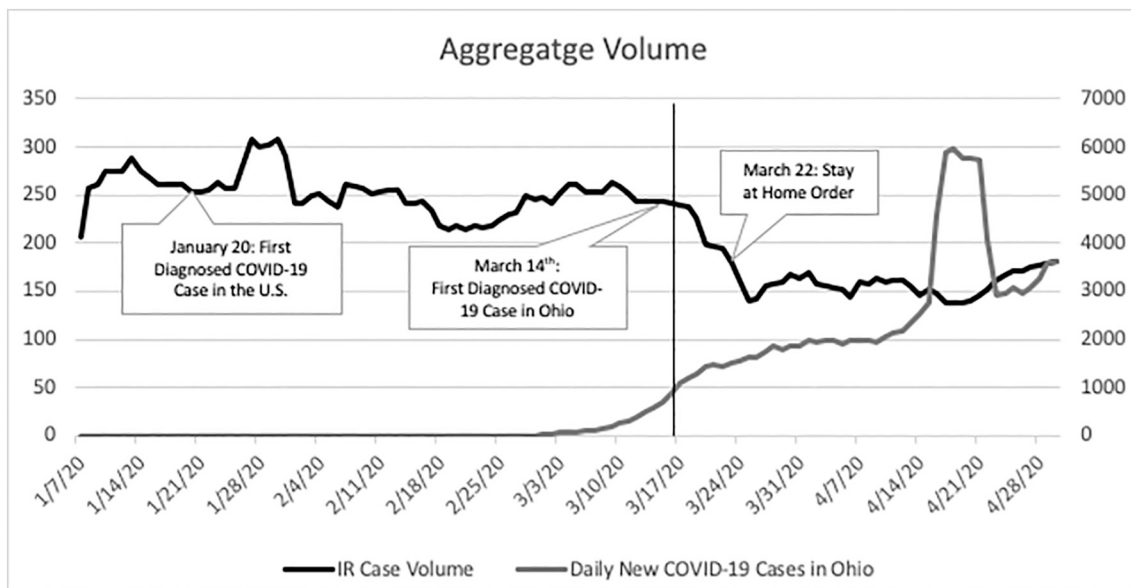


Fig. 1. The seven-day aggregate volume of 2020 IR case volume from all locations spanning from 1/7/20 through 4/30/20. The vertical line at 3/17/20 delineates the state mandated shutdown of non-essential procedures. Seven-day aggregate values for new daily COVID-19 cases in the state in question are superimposed on secondary Y axis.

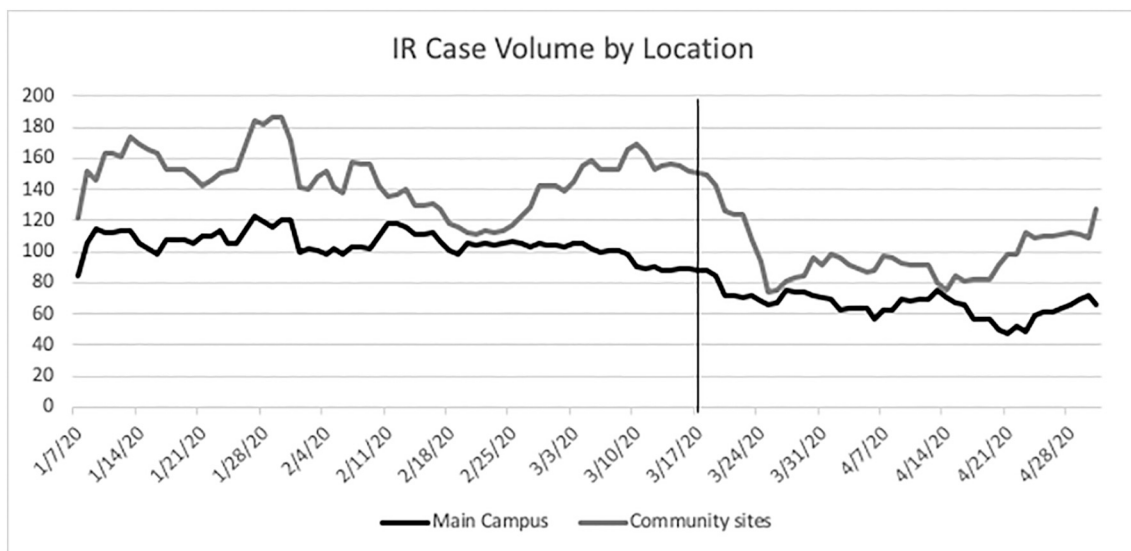


Fig. 2. The seven-day aggregate volume of Main Campus and Community sites from 1/7/20 through 4/30/20. The vertical line at 3/17/20 delineates the state mandated shutdown of non-essential procedures.

(55%) were outpatient and 483 (45%) were inpatient. Interventional Oncology, dialysis interventions and aspiration/drainage interventions contributed 29%, 14% and 20% of the total volume before the Governor’s order and 32%, 16% and 26% during the Governor’s order, respectively. There was no significant difference in the proportion of Interventional Oncology ($p = 0.16$) and dialysis interventions ($p = 0.08$) between the two time periods. The proportion of aspiration/drainage interventions were significantly higher during the Governor’s order ($p < 0.05$). The types of IR procedures performed during this period are provided in [Table 1](#).

4. Discussion

This study highlights the value of IR services in a large healthcare system in Ohio during the initial phase of the COVID-19 initial phases

and subsequent state mandated shutdown of non-essential procedures. Although IR procedural volumes overall showed a sizeable decrease, outpatient IR volumes were less affected compared to outpatient DR volumes. These findings may partially be attributed to a large subset of outpatient IR procedures that remained time sensitive in nature. A large health system actually noted they were able to reschedule a substantial volume of outpatient-based diagnostic imaging. However, careful attention was paid to IR scheduling with frequent exceptions made for IR procedures.⁷ Additionally, although an exact cause remains difficult to delineate, other surgical and procedural specialties also experienced a more pronounced decrease in case volume compared to IR. The Ohio Governor’s department of health order defined any non-essential procedure as a procedure that can be delayed without undue risk to the current or future health of the patient.⁸ This finding may underscore the notion that a substantial number of IR procedures were unable to be

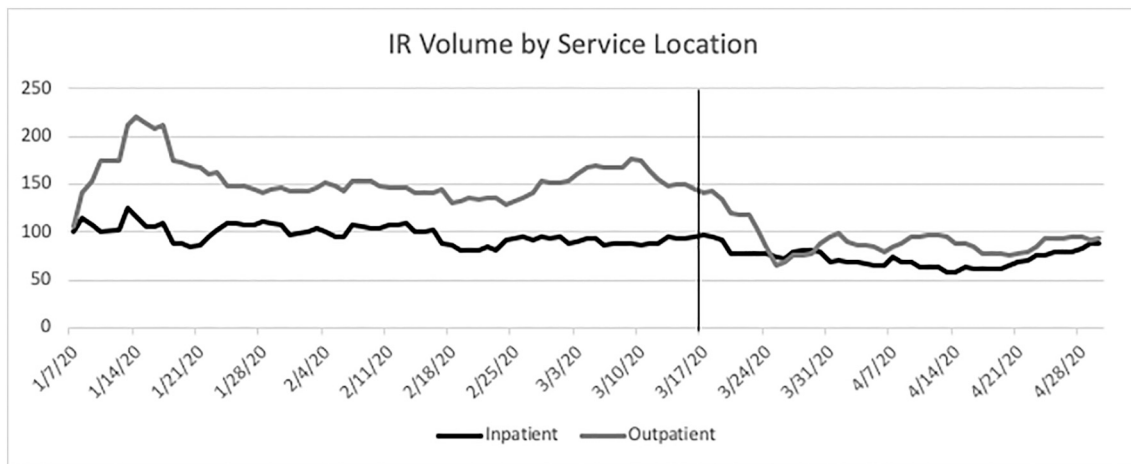


Fig. 3. The seven-day aggregate IR case volume for Inpatient and Outpatient procedures dated from 1/7/20 through 4/30/20, the vertical line at 3/17/20 delineates the state mandated shutdown of non-essential procedures.

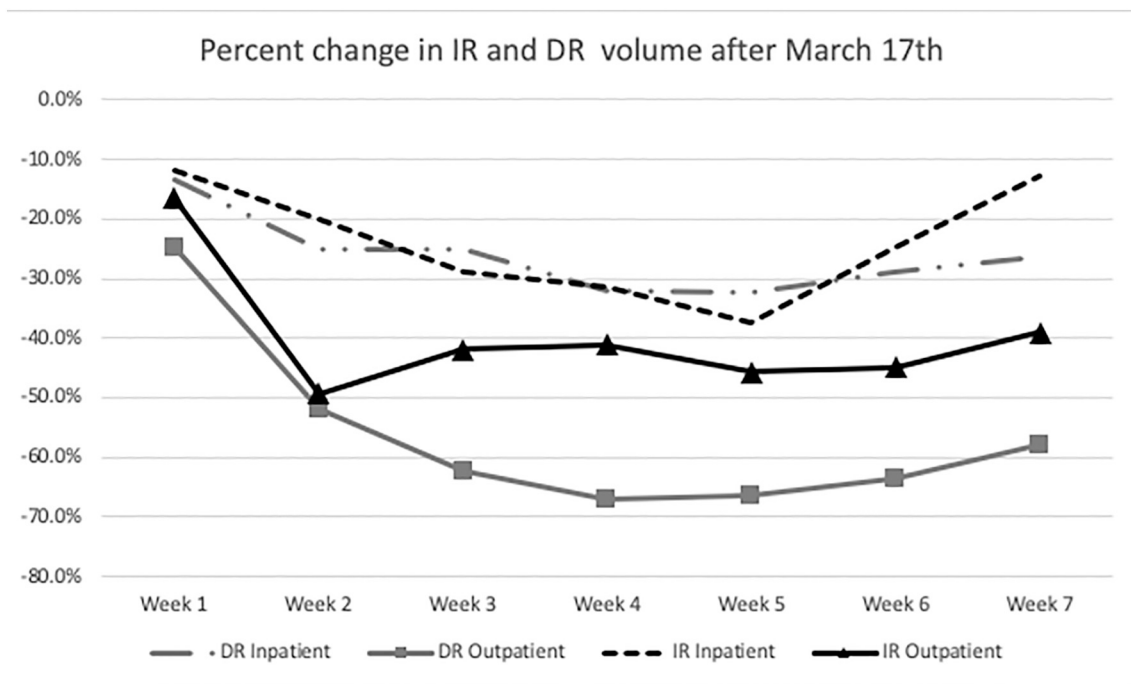


Fig. 4. Percentage change from average weekly baseline volume (1/7/20 through 3/16/20) in seven-day aggregate case volume for Interventional and Diagnostic Radiology stratified by service location.

delayed due to their central role in patient care.

When compared to baseline IR volume in the preceding months, there was a 25% decrease in the average weekly inpatient procedure volume and 41% decrease in outpatient procedure volume during the state mandate timeframe. In comparison to IR, DR saw a 22% decrease in inpatient procedure volume but a much higher 57% decrease in the outpatient procedure volume during the same time period. During the six weeks of Governors’ order, a total of 1077 procedures were performed in IR in our healthcare system and 55% of these were outpatient procedures. This observation highlights the variability within Radiology departments, namely IR and DR in what is considered essential outpatient service during a health crisis like COVID-19.

In our health care system, Interventional Oncology related interventions entailed a sizeable number of outpatient IR volume and overall Interventional Oncology volumes demonstrated no statistically significant change following the state mandated shutdown. These

procedures included tissue diagnostic procedures, placement of mediports, locoregional therapy as well as comfort providing procedures like thoracentesis and paracentesis. These findings are likely due to the impact on patient status with a delay in care. Additionally, we found that dialysis related procedures did not show a significant decrease in volume during the initial phase, also indicating the time sensitive nature of these procedures.⁹ Although no data has been reported on the matter, outpatient procedures may be safer from a COVID-19 disease transmission standpoint for patients as well as health care workers, as entrance into health care facilities themselves carries some risk in the COVID-19 era.^{9,10} Outpatient volumes also have a larger impact on overall revenue for a hospital system with recent literature demonstrating a nearly 50% revenue loss for a large Midwest health system during the initial 8 weeks of the COVID-19 health crisis.¹¹

A large hospital system in Boston observed a 57% decrease in their hospital procedural volume and a 45% decrease in their outpatient

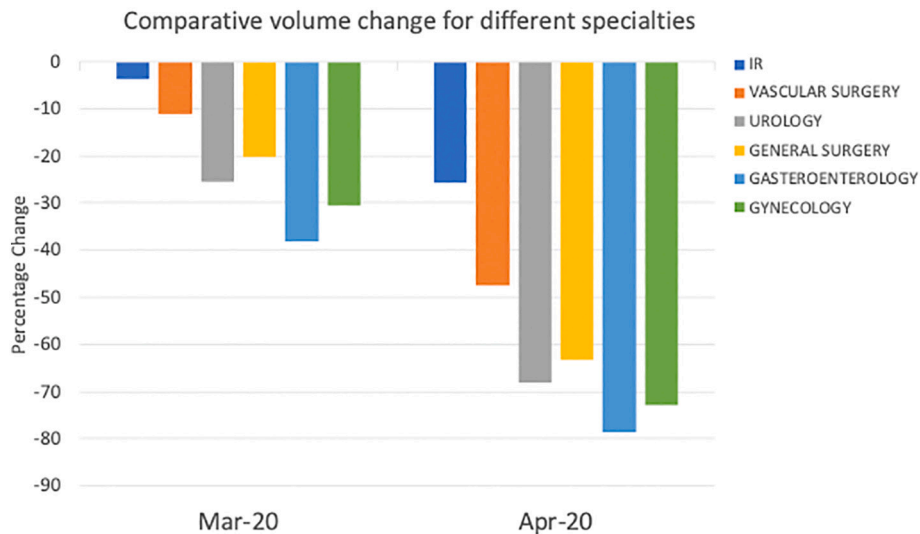


Fig. 5. Comparison of change in surgery/procedural volume for annotated specialties in March 2020 and April 2020 using a 6-month aggregate baseline (January 2019 through April 2019 and January 2020 through February 2020).

Table 1

Type of procedures performed in IR from March 17th to April 30th during the state mandated shutdown of non-essential procedures and the preceding 6 weeks February 4th–March 16th.

	February 4th–March 16th 2020	March 17th–April 30th 2020 (Governor’s Order)
Inpatient	588/1518 (38.7%)	483/1077 (44.8%)
Outpatient	930/1518 (61.3%)	594/1077 (55.2%)
Interventional oncology	442/1518 (29.1%)	341/1077 (31.7%)
Lung biopsies	39	35
All other FNA and biopsies	310	178
Mediport placement	68	98
Percutaneous thermal ablation	10	8
TACE/mapping MAA/Y90	15	22
Dialysis interventions	209/1518 (13.8%)	175/1077 (16.2%)
Temporary dialysis catheter	87	54
Tunneled venous catheter	93	98
AVF/AVG/thrombolysis/angioplasty	29	23
Aspiration/drainage interventions	310/1518 (20.4)	283/1077 (26.3%)
Thoracentesis	94	131
Paracentesis	161	119
Percutaneous cholecystostomy	3	5
Percutaneous biliary drainage	7	8
Percutaneous nephrostomy/nephroureteral stent	45	20
Enteral access for feeding (gastrostomy, duodenostomy, jejunostomy, nasogastric tube placement)	12	14
TIPS	2	1
IVC filter placement	11	5
IVC filter removal	6	2
Tube evaluation, sinogram, tube change, tube removal	92	50
Other	350	137
Total	1518	1077

volume when compared to 2019. Interestingly, their off campus outpatient IR suite showed an increase of 23% during the pandemic.⁶ Although these findings may raise concern that outpatient procedures were continuously performed to maintain outpatient revenue streams, they alternatively may underscore the utility of spatial segregation of

the outpatient IR suites. The aforementioned hospital system and involved IR department also underwent a large-scale reassignment and repurposing secondary to increased demand on resources during the same time frame. Therefore, their increased outpatient volume despite these concurrent measures highlights the central and essential role of outpatient based IR procedures.

In another large medical system in New York City, which was one of the hardest hit areas in the United States, outpatient volume significantly decreased. Previously, it accounted for greater than 60% pre-pandemic procedural volume to accounting for less than 40% during the pandemic.¹² However, IR skillset was utilized to help shoulder the weight of the overwhelmed healthcare system. This included redeploying staff in the critical care setting with the goal of providing bed-side procedures, facilitating procedures in light of diminishing resources, namely providing additional percutaneous gastrostomy tube placements due to decreased availability of endoscopy services and carefully planning procedures under sedation which were usually completed with anesthesia. These efforts highlight the versatility and flexibility of IR and the capacity to incorporate skills into mainstream frontline response during a crisis. Although enlisted for deployment, IRs at our institute did not have to provide support to other services as our system capacity was not overwhelmed.

Another observation at our institute was the variability in the procedural and surgical volume changes for various subspecialties. While IR observed a 3% and 25% decrease in volumes for the months of March and April 2020, respectively, there was a much larger decrease in volume for other specialties like Vascular Surgery, Urology, General Surgery, Gastroenterology and Gynecology as seen in Fig. 5. Although volumes in other procedural specialties demonstrated decreases in March 2020, the aggregated data from March included procedural volume both before and after the state mandated shutdown. This slightly limits its utility in highlighting differences relative to the shutdown. However, the relative decreases in surgical and procedural volume for the aforementioned specialties were much more pronounced in April 2020 in comparison to their baseline monthly volumes. For example, Gastroenterology and Gynecology demonstrated 79% and 73% decreases in April 2020, respectively. These differences may relate to the definition of essential procedures in these procedural specialties compared to classification of essential procedures in IR during this crisis.

Stratification of procedures into essential and nonessential categories may also partly account for our observed relative increase in number of drainage procedures after the state mandated shutdown. Policy from our health system closely mirrored the policies delineated

on the available Society of Interventional Radiology COVID-19 toolkit.¹³ Drainage procedures accounted for approximately 20% of all IR procedures prior to the shutdown and 26% of all procedures following the shutdown. Similar results were also reported in Canada where percutaneous drainage remained among the most frequently performed procedures in the acute setting during the initial phase of COVID-19.¹⁴ Categorization of procedures may also more efficiently re-allocate personnel and resources, including personal protective equipment. Compared to IR, surgical specialties more often require general anesthesia for their procedures which in the context of COVID-19 is considered higher risk from an aerosol-generating potential. Direct comparison of procedures, for example port placements, have proven to be more cost-effective when placed using minimally invasive image guided techniques utilized by IR rather than operating room placement by surgeons.¹⁵

More efficient resource allocation and further utilization of outpatient IR labs during the ongoing health and economic crisis secondary to COVID-19 may help ease the financial burden of health care systems. These findings are of special concern as American hospitals and health systems have lost an estimated \$50.7 billion per month due to COVID-19.¹⁶ These observations also lend to the discussion of ‘redefining essential’ for outpatient office-based IR practices and ambulatory surgery centers.¹⁷ The focus during the initial phase of COVID-19 was on hospitals. This led to underutilization of the resources and manpower of outpatient-based labs (OBLs) or ambulatory surgery centers (ASCs) that were asked to completely shut down. This may partially account for avoidable delays in care. Inclusion of IR and OBLs/ASCs in the emergency preparedness plans may be a beneficial consideration moving forward.

In our health system, the lowest outpatient IR volume was observed in week 2 (49%) of the initial surge phase. In comparison, the largest health system in the hardest hit state like New York it was noted in week 6 (56%). Unlike Ohio, an endemic area like New York showed a continuous decline during the initial six to seven-week surge. These differences highlight the difficulty in generalizing trends based on geographic disposition during the initial phases of COVID-19. Different regions and locales may be experiencing different levels of “surge” and “peak” phases which may significantly alter the resources and availability of IR within health care systems.

Our study has various limitations given its retrospective nature in a single, large heterogeneous health care system. Differences in procedure codes utilized contributes to variability in data collection, however careful consistency was maintained for data analysis between various time periods. The daily procedural volumes for IR and DR were available to compile seven-day rolling aggregates, however the same values for other surgical specialties were not completely available to us. Instead, only monthly values were obtained, which limits specific analysis relative to the exact date of the shutdown. Additional limitations in comparison included defining baseline values in the weeks and months prior to the Governor’s mandate to halt non-essential procedures. Although procedures were allowed to be completed prior to the mandate, patients and providers were rescheduling procedures even prior to the state mandate. Procedure volumes for other specialties were exclusively those performed in operating rooms. Those performed elsewhere were not available, for example the Vascular Surgery procedures in Radiology. Direct comparison with 2019 volumes were not performed due to inherent variability in our practice as well as a different number of IR staff in either year. However, as we focused our study on the Governor’s order to stop all non-essential procedures, volumes between January 1, 2020 and March 17, 2020 were considered the most appropriate available baseline evaluation. Categorization of type of IR procedures can be difficult. For example, many thoracentesis and paracentesis procedures

are performed on oncology patients which could be classified into the Interventional Oncology category. However, the methodology was maintained during the different time periods.

In conclusion, the COVID-19 pandemic had a significant impact on IR procedural volumes, however outpatient volumes for IR were less impacted than for DR. Also, IR was less impacted compared to other surgical specialties’ procedural volumes. Our observations can be used to explore the potential role of IR in emergency preparedness protocols, redefining ‘essential’ procedures for different IR practices, evaluating revenue benefits by further boosting essential outpatient procedural volume, acknowledging an ever-growing and definable difference between IR and DR practice, and triaging resource allocation at the department and system level during a health crisis like COVID-19.

Declaration of competing interest

None.

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