Impact of COVID-19 Pandemic on Interventional Radiology Practice—A Multicenter Observational Study

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Abstract

Background The COVID-19 pandemic has brought unprecedented challenges to health care services including interventional radiology (IR). Treating COVID-19 infected patients became a priority; furthermore, government policies of differing elective procedures and the public's fear of contacting COVID-19 have impacted IR workload worldwide. The aim of this study was to evaluate the impact of the COVID-19 pandemic on the workflow in six vascular IR centers located across India.

Methods The data were collected retrospectively from April 1 to June 30, 2020. All the six centers were staffed by the alumni of a single parent center located in India. Data was also collected from the same time period in 2019 for comparison.

Results A total of 893 patients were treated from April 1 to June 30, 2019, and 419 were treated during the same period in 2020 during the pandemic, a 53% case volume reduction (95% CI:28. 56–129.44; $p < 0.001$). The month of April had the largest case volume reduction (66%, 95% CI: 13.57–50.43; $p < 0.001$). Elective procedures showed an 85% reduction (95% CI: 9.62–91.71; $p < 0.001$). Venous interventions showed the highest reduction of 76% (95% CI: 0.75–67.75; $p < 0.001$). Neurological emergencies, dialysis-related interventions, and nonvascular procedures did not show a significant change. No patient tested positive for COVID-19 prior to the procedure; however, one patient who was treated emergently was found to be positive later.

Conclusion COVID-19 pandemic has severely impacted IR practice across India. Workload reduction was more profound at the beginning of the COVID-19 pandemic with a gradual improvement over time.

Keywords
- COVID-19
- interventional radiology
- impact on health care

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Introduction

Novel coronavirus or "severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)" pneumonia first originated in Wuhan, China, in December 2019.[1] India reported its first case on January 30, 2020, which was followed by a resurgence of cases in the beginning of March. This compelled the federal government of India to impose a nationwide lockdown starting from March 24, 2020, which resulted in a major shift in the pattern of work and hospital working guidelines. Dispensing medical services for both COVID and non–COVID-19 patients became a challenge. Further, protection of the medical workforce treating COVID-19 infected patients became a necessity.[2-4]

Because of a variety of procedures supporting multiple disciplines of medicine, interventional radiology (IR) plays an important role in day-to-day patient care in several difficult situations.[5] Thus, the workers in this specialty have a substantial risk of contracting and transmitting infection secondary to close contact with patients.[6-8] IR specific guidelines were put in place to limit the transmission primarily through physical distancing, use of personal protection equipment (PPE), and disinfection. Additionally, specific steps were recommended to optimize resources and manpower.[9] This resulted in a reduction in workload, affecting some procedures more than the others. We aimed to study the impact of the ongoing COVID-19 pandemic on IR workflow in different IR centers across India during the first 3 months of its spread in India.

Methods

The study was conducted at six vascular IR centers. These centers were staffed by the alumni of a single center and were located in different geographical areas across India. Data was collected retrospectively for the period from the April 1 to June 30, 2020, during different phases of the government-imposed lockdowns: phase 1 (March 25–April 14), phase 2 (April15–May 3), phase 3 (May 4–17), phase 4 (May 18–31), and unlock 1.0 (June 1–30). Data from April 1, 2019 to June 30, 2019 was also retrieved for comparison. All vascular and nonvascular invasive diagnostic and therapeutic procedures, central line or dialysis catheter insertion, and image-guided procedures such as biliary and abscess drainages were included in the study.

Image-guided biopsies and fine needle aspiration cytology (FNAC) were excluded due to the inability to retrieve comparative data from 2019.

Data Recording

Retrospective data of the total number of patients treated during the corresponding periods (April 1–June 30) in 2019 and 2020 were retrieved from the medical records and analyzed. Various demographic, clinical, and procedural variables that were included are shown in ►**Table 1**. No significant demographic differences were noted during the pandemic as compared with 2019. The mean age was 51 years in 2019 versus 49 years in 2020. No difference was seen in gender proportions: males (54% reduction) and females (52% reduction). However, at one center exclusively devoted to the treatment of varicose veins, the patient cohort was younger (mean 33 years during the pandemic vs. 52 years during 2019), as elective procedures were selectively postponed in the elderly patients (age > 60 years) during the pandemic.

All procedures were categorized according to the Society of Interventional Radiology (SIR) classification of case urgency.[10]

Variation in the number of procedures was analyzed after classifying them based on the month in which it was done, type of procedure, and the involved organ system.

Interventional Radiology (IR) Practice Reorganization

All patients prior to undergoing any IR procedure were screened for symptoms of COVID-19 infection, such as fever, cough, or symptomatic personal contacts. High-resolution computed tomography (HRCT) chest or reverse transcription polymerase chain reaction (RT-PCR) was done whenever possible before the procedure or according to the local hospital guidelines. HRCT findings were classified according to the COVID-19 Reporting and Data System (CORADS) score.[11] CORADS 4 and 5 were considered highly suggestive of COVID-19 infection, whereas CORADS 3 was considered suspicious.

All health care workers who were actively involved in treatment compulsorily donned full airborne personal protective equipment (PPE: N95 mask, face shield, gown, and gloves) as per the Indian Council of Medical Research (ICMR) and Ministry of Health and Family Welfare (MOHFW) guideline before entering the angiography room, irrespective of the patient's COVID-19 status.[12] All patients were made to wear surgical masks to prevent droplet dissemination whenever possible.

In the majority of the cases, local anesthesia or mild sedation was preferred. Patients who required general anesthesia were intubated in emergency or ICU and brought to the interventional suite. If intubation was required during the procedure, it was performed by the attending anesthesiologist with adequate aerosol-preventive measures.

Health Care Worker Surveillance

The RT-PCR/Tru-NAT test was performed only if a health care worker was symptomatic or had unprotected exposure to a patient with confirmed or suspected COVID-19.

Statistical Analysis

The data was processed in Microsoft Excel and IBM SPSS Statistics 20.0; statistical averages and relevant proportions were calculated. Confidence intervals were calculated at 95%. Two-proportion z-test was used for the level of significance (p values) and the Chi-square test was used for association. The statistical significance threshold was set at 5%. Tables and charts were prepared for simplification and a better understanding of data.

Table 1 Demographic, clinical and procedure-related parameters

Parameters	Age
	Sex
	Classification of case urgency
	Diagnosis
	Diagnostic/interventional
	Intervention performed
	System involved (neuro/GIT/ peripheral vascular/dialysis-related/venous/ aortic/ bleeding)
	Vascular/ nonvascular
	Technical outcome (success/failure)
	Clinical outcome (recovered/ disabled/died)
	Pre-procedure test for COVID-19 (PCR/CT chest/others)
	Time from admission to procedure (hours)
	Covid status
	Personal protection (PPE/N 95/N 95 + visor/triple layer mask)
Emergent	All trauma cases
	Acute bleeding
	Hemodialysis access thrombectomy
	Urgent IVC filter placement, DVT endovascular treatment
	Sepsis-related interventions (drainage, symptomatic effusions)
	Stroke thrombectomy
	Subarachnoid hemorrhage, acute limb ischemia
Urgent	Interventional oncology related treatment (ablation, SIRT, TACE), ports, catheters, biopsy for initial diagnosis and staging of cancer)
	Venous access for specific indications (stem cell therapy, intravenous antibiotics, chemotherapy)
	Secondary prevention of stroke (carotid/ICAD stenting), AVM/DAVF embolization
	Dialysis-related interventions
Elective	Routine drain or line changes
	Vein sampling (adrenal or petrosal, etc.)
	UFE, gonadal vein embolization
	IVC filter retrievals, chronic venous recanalization, EVLT, VenaSeal, sclerotherapy
	Arteriovenous or venous malformations
	Routine PAD
	Research biopsies
	Thyroid biopsies, treatment of unruptured aneurysm/AVM

Abbreviations: AVM, arteriovenous malformation; DAF, dural arteriovenous fistula; DVT, deep vein thrombosis; EVLT, endovenous laser treatment; GIT, gastrointestinal tract; ICAD, intracranial atherosclerotic disease; IVC, inferior vena cava; SIRT, selective internal radiotherapy; TACE, transarterial chemoembolization; UFE, uterine fibroid embolization.

Results

A total of 893 patients were treated from April 1 to June 30, 2019, and 419 patients were treated during the corresponding period during the COVID-19 pandemic in 2020, which is a 53% reduction in workload (95% CI:28.56–129.44; $p < 0.001$). The month of April 2020 showed a 66% reduction in the number of procedures (95% CI: 13.57–50.43; $p < 0.001$), the month of May 2020 showed a 54% reduction (95%CI: 13.18–41.49; $p < 0.001$), and June 2020 showed a 40% reduction (95% CI: 0.01–29.32; $p < 0.001$) (►**Fig. 1**, ►**Table 2**).

Emergent procedures showed 45% reduction (95% CI: − 5.90–41.90; $p < 0.001$), urgent procedures showed 16% reduction (95% CI: − 16.21–29.54; $p = 0.01$), and elective procedures showed 85% reduction, (95% CI: 9.62–91.71; $p < 0.001$) (►**Table 2**).

Among the various categories of interventions, venous interventions showed highest (76%) reduction (95% CI: 0.75–67.75; $p < 0.001$), bleeding-related interventions showed a 71% reduction, (95% CI: 0.75–15.92; $p < 0.001$), and neurointerventions showed a 27% reduction, (95% CI: − 3.91–19.91; $p < 0.001$). Dialysis-related interventions showed the lowest (2%) reduction, (95% CI: − 9.07–7.07; $p = 1.00$) (►**Fig. 2**, ►**Table 2**).

Chi-square test was done to ascertain association between impact on workload and COVID-19 pandemic. Among the 21 parameters studied, 13 had a p value < 0.05, showing that the change in workload was indeed due to the pandemic (►**Table 3**).

Among specific procedures, a few showed marginal increase in numbers, but they were not statistically significant. Acute deep venous thrombosis (DVT) interventions showed a 75% increase (95% CI: − 2.35–1.35; p = 0.375), stroke thrombectomy showed a 34% increase (95% CI: − 3.42–2.12; p = 0.409), and subarachnoid hemorrhage (SAH)-related interventions showed a 17% increase (95% CI: − 2.73–1.40; p = 0.625). Procedures such as varicose vein interventions showed the highest (91%) reduction, (95% CI: − 7.35–62.35; p < 0.001), followed by transarterial chemoembolization (TACE) for hepatocellular carcinoma, which showed 87% reduction (95% CI: − 0.09–15.09; p < 0.001) (►**Fig. 3**, ►**Table 4**).

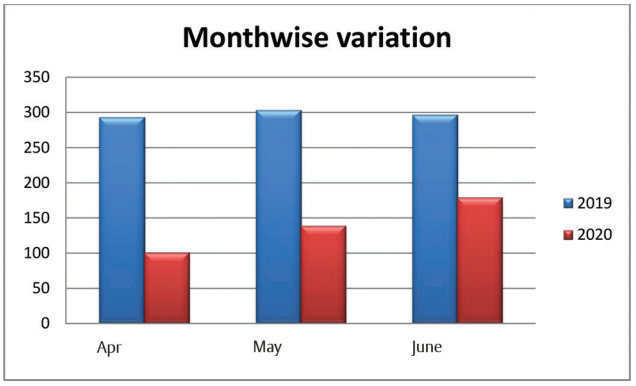

Fig. 1 Shows month-on-month variation in cases before and during the pandemic. Note similar monthly numbers in the year 2019 but a reduction in year 2020, which gradually improved along with relaxation in lockdown.

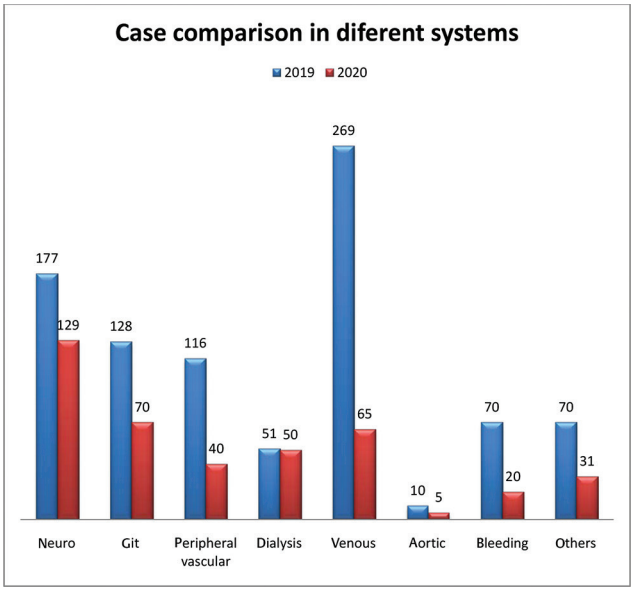

Fig. 2 Shows a comparison in numbers of cases treated from different organ systems during the same period of 2019 and 2020.

Table 2 Comparisonof number of patients among different parameters in COVID-19 and non COVID-19 period

		Total	Non COVID-19 year 2019	COVID-19 year 2020	Change in %	p-Value
Gender	Male	828	567	261	− 54%	**< 0.001**
	Female	484	326	158	− 52%	**< 0.001**
Month	April	394	293	101	− 66%	**< 0.001**
	May	442	303	139	− 54%	**< 0.001**
	June	476	297	179	− 40%	**< 0.001**
Urgency	Emergent	443	286	157	− 45%	**< 0.001**
	Urgent	454	247	207	− 16%	**0.01**
	Elective	414	359	55	− 85%	**< 0.001**
Type	Diagnostic	262	186	76	− 59%	**< 0.001**
	Interventional	977	644	333	− 48%	**< 0.001**
System	Neuro	306	177	129	− 27%	**< 0.001**
	GIT	198	128	70	− 45%	**<0.001**
	Peripheral vascular	156	116	40	− 66%	**< 0.001**
	Dialysis	101	51	50	− 2%	1.000
	Venous	334	269	65	− 76%	**< 0.001**
	Aortic	15	10	5	− 50%	0.144
	Bleeding	90	70	20	− 71%	**< 0.001**
	Others	101	70	31	− 56%	**< 0.001**
Category	Vascular	1151	806	345	− 57%	**< 0.001**
	Non-vascular	161	87	74	− 15%	0.181
TOTAL		**1312**	**893**	**419**	**− 53%**	**< 0.001**

Note: Values in bold are statistically significant.

Table 3 Association of number of patients with different parameters in COVID-19 and non COVID-19 period among different hospitals

Parameters		Non COVID-19 year (2019)							COVID-19 year (2020)							*p*-Value
		H-1	H-2	H-3	H-4	H-5	H-6	Total	H-1	H-2	H-3	H-4	H-5	H-6	Total	
Gender	Male	196	79	86	45	106	55	**567**	79	37	42	31	65	7	**261**	**0.024**
	Female	114	43	46	36	50	37	**326**	58	18	30	14	31	7	**158**	**0.007**
Month	April	102	41	45	27	48	30	**293**	36	11	16	10	28	0	**101**	**0.03**
	May	104	43	38	30	51	37	**303**	52	18	21	11	33	4	**139**	**0.012**
	June	104	38	49	24	57	25	**297**	49	26	35	24	35	10	**179**	**0.014**
Urgency	Emergent	90	39	51	17	89	0	**286**	67	18	38	16	18	0	**157**	0.113
	Urgent	93	18	63	21	52	0	**247**	55	26	34	23	69	0	**207**	0.07
	Elective	126	65	18	43	15	92	**359**	15	11	0	6	9	14	**55**	**0.04**
Type	Diagnostic	7	28	32	18	9	92	**186**	33	13	12	3	15	0	**76**	0.16
	Interventional	240	94	100	63	147	0	**644**	104	32	60	42	81	14	**333**	**0.003**
System	Neuro	85	28	37	12	15	0	**177**	58	16	26	9	20	0	**129**	**0.001**
	GIT	21	9	35	16	47	0	**128**	7	9	26	9	19	0	**70**	**0.03**
	Peripheral vascular	40	25	16	19	16	0	**116**	17	5	6	6	6	0	**40**	**0.008**
	Dialysis	16	6	9	5	17	0	**51**	20	7	4	19	9	0	**50**	0.35
	Venous	79	38	15	24	21	92	**269**	10	18	0	2	21	14	**65**	0.64
	Aortic	5	2	3	0	0	0	**10**	1	0	3	0	1	0	**5**	0.35
	Bleeding	23	14	14	0	19	0	**70**	11	0	7	0	2	0	**20**	0.12
	Others	41	0	3	5	21	0	**70**	13	0	0	0	18	0	**31**	**0.04**
Category	Vascular	289	118	108	69	130	92	**806**	134	48	53	24	72	14	**345**	**0.003**
	Nonvascular	21	4	24	12	26	0	**87**	3	7	19	21	24	0	**74**	0.18
Total		**310**	**122**	**132**	**81**	**156**	**92**	**893**	**137**	**55**	**72**	**45**	**96**	**14**	**419**	**0.01**

Abbreviation: GIT, gastrointestinal tract.

There was a wide variation in the testing and HRCT protocol among different participating hospitals due to evolving protocols. One hundred and eight patients underwent HRCT thorax and 158 underwent RT-PCR before the procedure. None of the patients had a positive RT-PCR or findings suggestive of COVID-19 infection on CT thorax (CORADS score ≥ 3). Nine health care workers were tested using RT-PCR for interstate travel or due to the presence of mild symptoms and all were negative (►**Fig. 4**).

Discussion

The COVID-19 pandemic has brought in unprecedented challenges for medical care in terms of a decrease in workload, infection control, and workforce management. Many recent publications have focused on sharing their experiences and potential challenges relevant to IR services.[6,8,13] However, to the best of our knowledge, there are no published multicenter data regarding the real impact of the COVID-19 pandemic on IR practice across India.

We included a total of six centers located in different geographical areas within India to understand the overall trend. Five of these centers were providing interventions of all organ systems and were tertiary care hospitals in public (1), private (3), and trust setup (1). One of them was a dedicated varicose vein intervention center. It was important to understand the impact on standalone centers such as varicose vein intervention centers because the procedure per se is often elective.

Our study showed that there was a predictable reduction in the number of IR procedures due to the lockdown. During these 3 months, there was an overall 53% reduction in work, which was more in April 2020 and slowly improved in May 2020 and June 2020 (66 vs. 54 vs. 40%). As elective procedures were postponed, the impact was even higher in the elective procedures' subgroup (85%). A study published by Lezzi et al reported a 48% overall workload reduction due to the COVID-19 pandemic.[14]

Neurointerventions were among the least affected, as most of these procedures fall under emergencies such as stroke, SAH, and intracerebral hemorrhage. Neurointerventional procedures such as stroke thrombectomy and endovascular therapy for ruptured aneurysm increased marginally (31%, $p = 0.409$ and 14%, $p = 0.625$, respectively). This increase was probably due to the avoidance of an aerosol-generating neurosurgical procedures during the pandemic or closure

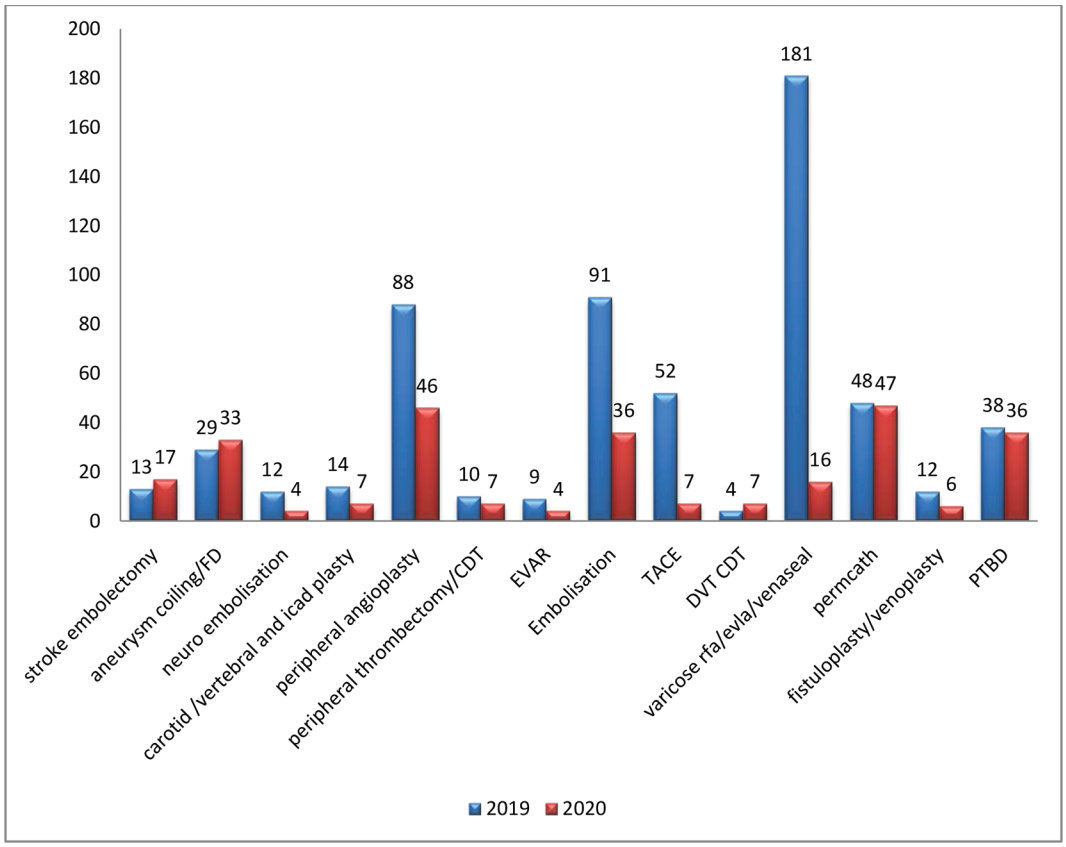

Fig. 3 Shows a comparison in the numbers of different procedures performed during the same period of 2019 and 2020. Not much change was noted in emergency procedures but a significant reduction in elective procedures. CDT, catheter directed thrombolysis; DVT, deep vein thrombosis; EVAR, endovascular aneurysm repair; FD, Flow diverter; PTBD, percutaneous transhepatic biliary drainage; TACE, transarterial chemoembolization.

Table 4 Comparison of number of patients among different vascular intervention in COVID-19 and non COVID-19 period

Procedure	Total	Non COVID-19 year 2019	COVID-19 year 2020	Change in %	*p*-Value
Stroke thrombectomy	30	13	17	31%	0.409
Aneurysm coiling/FD	62	29	33	14%	0.625
Neuroembolization	16	12	4	− 67%	**0.013**
Carotid/vertebral and ICAD plasty	21	14	7	− 50%	**0.05**
Peripheral angioplasty	134	88	46	− 48%	**< 0.001**
Peripheral thrombectomy/CDT	17	10	7	− 30%	0.512
EVAR	13	9	4	− 56%	0.122
Embolization	127	91	36	− 60%	**< 0.001**
TACE	59	52	7	− 87%	**< 0.001**
DVT–CDT	11	4	7	75%	0.375
Varicose RFA/EVLA/VenaSeal	197	181	16	− 91%	**< 0.001**
Permcath	95	48	47	− 2%	0.896
Fistuloplasty/venoplasty	18	12	6	− 50%	0.088
PTBD	74	38	36	− 5%	0.937
Total	**874**	**601**	**273**	**− 55%**	**< 0.001**

Abbreviations: CDT, catheter-directed thrombolysis; DVT, deep vein thrombosis; EVAR, endovascular aneurysm repair; EVLA, endovenous laser ablation; FD, flow diversion; ICAD, intracranial atherosclerotic disease; PTBD, percutaneous transhepatic biliary drainage; RFA, radiofrequency ablation; TACE, transarterial chemoembolization.
Note: Values in bold are statistically significant.

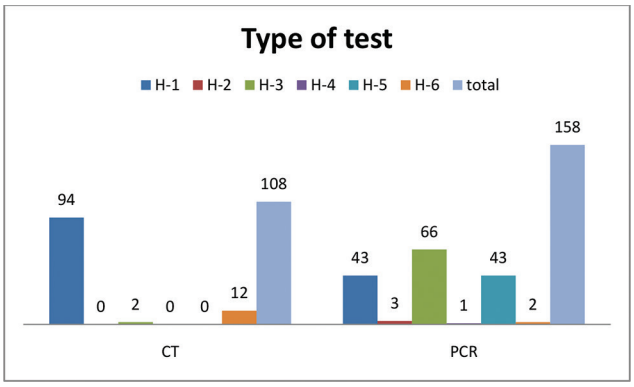

Fig. 4 Shows the number of patients who underwent pre-procedure CT or RT-PCR to diagnose COVID-19 positivity. Note the variation in testing strategy among different hospitals.

of smaller centers. The number of elective neurointerventional procedures such as carotid or vertebral stenting (33%, $p = 0.05$) and embolization (50%, $p = 0.013$) decreased significantly.

There was overall significant reduction in peripheral vascular interventions (48%, $p < 0.001$) and peripheral embolization (43%, $p < 0.001$) but no significant change in the number of acute limb ischemia (17%, $p = 0.512$). As expected, elective venous interventions showed the highest reduction (76%, $p < 0.0010$), especially varicose vein interventions (91%, $p < 0.0010$). Acute DVT treatment increased by 75% but was not statistically significant ($p = 0.375$), probably due to selective referral or year-on-year variability. We did not see any case related to COVID-19 hypercoagulability.

Dialysis-related procedures did not show a significant change (1%, $p = 1.00$), as these were essential services. Nonvascular procedures also did not show a significant reduction (8%, $p = 0.181$), as these were essential services.

A significant association ($p < 0.05$) was found between the COVID-19 pandemic and the total workload, elective procedures, interventional procedures, and vascular procedures. The change in workload was probably not due to other variables, for example, year-on-year variation, change in referral pattern, or change in the reputation of a particular hospital.

Limitations

The main limitation of our study is the nonuniformity of preprocedure COVID-19 testing. This was due to the limited availability of test kits and laboratories and stricter regulations by the government. Another problem is getting a test result early, especially in emergency cases, as in most of the centers, the results took more than 24 hours. In the beginning, emergency cases were done purely on clinical judgment without HRCT or RT-PCR.

The second limitation of the study is that no COVID-19 positive patient was treated during the study period. This could be because the geographical areas included in this study were in the initial phase of the disease spread and the relatively few positive patients were treated in specially designated hospitals. Hence, the risk of infection to health care workers could not be estimated.

The third limitation is a potential selection bias, as these centers are all staffed by the alumni of one center; hence, the repertoire of the cases may represent a similar practice pattern and need not necessarily represent the overall national trend.

The final limitation of the study is that we compared the data only with that from the previous year. A longer term comparative data would be more useful to differentiate the normal practice variation and the effect of the COVID-19 pandemic. However, our study, by showing the differences with a high statistical significance demonstrated that the changes encountered are less likely to be from practice variation.

Suggestions and Recommendations

As this pandemic is probably not ending any time soon and there are limited guidelines for health care operations during this crisis, IR services have to continuously care for patients.[15] IR facilities across India, where most hospitals have a single interventional radiologist with few supporting staff, have additional challenges in terms of delivering the essential services to patients while safeguarding the health care workers. Safety can be improved by making required changes in IR workflow, reducing contamination, performing bedside USG-guided procedures whenever possible, limiting movement or transportation of suspected or positive patients out of their room,[16] judicious testing, and strict adherence to using appropriate PPE.[17-19] By following these guidelines, cross-infection among patients and health care workers in the IR department can be minimized.[20]

Conclusion

During the early months of the COVID-19 pandemic, we observed a significant reduction in the number of procedures performed by IR practices across the country. Although our initial results showed a gradual recovery of case volumes, a longer term study spanning the entire duration of the pandemic would be helpful to understand the broader impact of the pandemic on the IR practice.

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