

How the Workload and Outcome of Imaging Examinations Changed During the COVID-19 Pandemic Lockdown

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Summary. *Background:* On March 9th, 2020, the Italian government decided to go into lockdown due to the COVID-19 pandemic, which led to changes in the workflow of radiological examinations. *Aims:* Aim of the study is to illustrate how the workload and outcome of radiological exams changed in a community hospital during the pandemic. *Methods and Material:* The exams performed in the radiology department from March 9th to March 29th, 2020 were retrospectively reviewed and compared to the exams conducted during the same time-period in 2019. Only exams coming from the emergency department (ED) were included. Two radiologists defined the cases as positive or negative findings, based on independent blind readings of the imaging studies. Categorical measurements are presented as frequency and percentages, and p-values are calculated using the Chi-squared test. *Results and Conclusions:* There was a significant reduction in the amount of exams performed in 2020: there were 143 (93|65% male, 60.7±21.5 years) patients who underwent radiological examinations from the ED vs. 485 (255|53% male, 51.2±24.8 years) in 2019. Furthermore, the total number of ED exams dropped from 699 (2019) to 215 (2020). However, the percentage of patients with a positive result was significantly higher in 2020 (69|48%) compared to 2019 (151|31%) ($p < .001$). The reduction of emergency radiological examinations might be a result of the movement restrictions enforced during the lockdown, and possible fear of the hospital as a contagious place. This translated to a relative increase of positive cases as only patients with very serious conditions were accessing the ED. (www.actabiomedica.it)

Keywords: COVID-19; Emergency Department; Findings; Lockdown; Pandemics; Workflow.

Introduction

The first cases of severe pneumonia of unknown etiology presented in December, 2019, followed by identification of SARS-CoV-2 as the responsible causing agent; ever since, infections by the coronavirus disease 2019 (COVID-19) continue to increase worldwide [1, 2, 3]. Italy was one of the most affected European countries with a high mortality rate [4, 5].

Starting on March 9th, 2020, the Italian prime minister effected a national lockdown, which entailed staying at home (excluding essential trips; e.g. to supermarkets, doctors, etc.), practicing social distancing, and temporarily closing non-essential businesses [6]; in spite of these policies, the virus continued to spread quickly and efficiently. By March 30th, 2020 there were 94,312 total cases nationally and 10,026 fatalities [7].

During the COVID-19 pandemic, the workflow of emergency departments (ED) had to adapt as a result of the new virus [8, 9]. The regular operations of the radiology department needed to change as well to face the outbreak and manage the SARS-CoV-2 positive patients, while safely handling the normal workflow of the hospital simultaneously [10, 11, 12]. To reduce the workload of the hospital and allow a better organization of hospitals, all non-urgent outpatient radiological exams were required to be rescheduled by law [6].

Several studies and surveys have investigated the reduction of the number of radiological examinations performed during the implementation of lockdown measurements in different countries; however, to the best of our knowledge, none of them provide insight into the changes in the outcome of radiological examinations during the lockdown measurements [13, 14, 15].

Therefore, the aim of this study was to understand how the workload of a radiologist changed during the pandemic, and explore how the lockdown measurements affected the types and outcomes of radiological exams performed in a community hospital's ED.

Material and methods

Study population

The local institutional review board approved this retrospective single-center study, which followed the protocol and principles of the Declaration of Helsinki, in accordance with the International Conference on Harmonization Tripartite Guideline for Good Clinical Practice. Written informed consent was waived because of the retrospective nature of the study.

We reviewed the imaging examinations performed in the radiology department of our hospital from March 9th to March 29th, 2020 and from March 9th to March 29th, 2019. We included consecutive patients coming from the ED who had at least one imaging exam performed: radiograph (XR), CT or sonography. If a patient was then admitted and received additional imaging during an inpatient stay, these additional exams were not included. Exclusion criteria were exams performed on patients not coming from the ED or exams performed on hospitalized patients. The

following was then recorded for each patient: baseline characteristics (obtained from medical records), clinical indication (reason for imaging exam), and radiological exams performed (number and types).

Image analysis

We defined a "positive exam" as the presence of an abnormal finding in at least one of the imaging examinations performed on the patient, which was also consistent with the clinical indication. For each patient, two radiologists (with 5 and 15 years of experience in emergency radiology) evaluated the exams independently, and rated said exams as either positive or negative, based on a blind review of the images and the correlation with the clinical indication. Since in Italy sonography exams are performed by the radiologists, the accompanying reports were also evaluated. If the radiologists differed in their exam ratings, a consensus was reached amongst them via discussion. For exams that presented with more than one finding, only one was selected via consensus according to the clinical request and clinical relevance (e.g. head trauma: hemorrhage from a nasal fracture).

Clinical indications and radiological findings were recorded and organized according to the following main categories: trauma, thoracic, abdominal, and neural. A sub-analysis of positive cases according to clinical indication and findings was also performed.

Hospital Characteristics

Our community hospital has approximately 20,000 annual ED visits, and has a total of 118 hospital beds distributed amongst the departments of: cardiology, general surgery, emergency medicine and surgery, general medicine, oncology, orthopedics, intensive care and functional recovery, and re-education medicine. The radiology department can perform conventional radiological examinations, sonography and CT scans (MRI is not present); it works 24/7 and serves the ED, inpatients and outpatients. During the COVID-19 pandemic all non-urgent outpatient radiological exams were required to be rescheduled by law [6]

Statistical analysis

Continuous variables were expressed as mean \pm SD and categorical measurements were presented as frequency and percentages. Cohen’s kappa (κ) was used to evaluate inter-observer agreement prior to reaching a consensus and *p*-values were calculated using the Chi-squared test. A *p*-value < 0.05 was considered statistically significant. We used MedCalc (version 18, MedCalc Software, Ostend, Belgium) for all statistical analyses.

Results

The total number of patients who underwent imaging examinations in our radiology department was 251 in the selected 3 weeks of 2020 and 851 in 2019. We excluded all hospitalized patients (99 from 2020 and 192 from 2019) and outpatients (9 from 2020 and 174 from 2019) (Figure 1); therefore, the total patients included in our analyses were 143 (93|65% male, 60.7 \pm 21.5 years) in 2020 and 485 (255|53% male, 51.2 \pm 24.8 years) in 2019 (Table 1). In 2020, there was a reduction of 69% in the exams performed from the ED (699 in 2019 and 215 in 2020). The types of exams performed in 2020 were 134 XR (62%), 49 CT (23%), and 32 sonography (15%), while in 2019 there were 473 XR (68%), 108 CT (15%), and 118 sonography (17%) (Table 1).

There was excellent interobserver agreement in the identification of positive exams for both 2020 (*K*=0.83, 0.74–0.92) and 2019 (*K*=0.81, 0.76–0.87). We found a significant relative increase (*P*<.001) in positive exams in 2020 (69 of 143, 48%) compared to 2019 (151 of 485, 31%). The main reason for performing an imaging exam was trauma in both 2020 (62 of 143, 43%) and 2019 (285 of 485, 59%) (*P*<.001); however, the second highest amount of exams performed in 2020 were because of thoracic reasons (43 of 143, 32%), while in 2019 they were abdominal (85 of 485, 18%) (*P*<.001) (Table 2). Table 3 shows the different radiological findings for 2020 and 2019 grouped in four main categories. Radiological trauma findings were the most encountered in both 2020

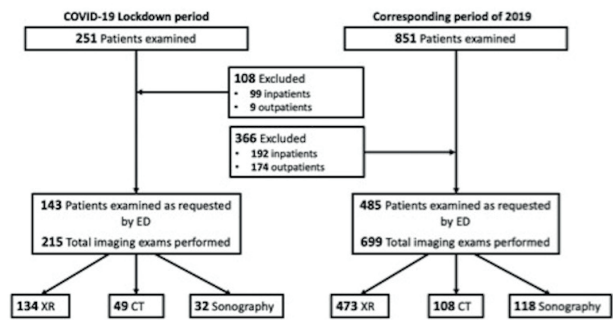


Figure 1. Flow diagram showing the excluded patients and total exams performed divided by type

Table 1. Demographics of Patients for 2019 and 2020; values are in number and percentage or mean \pm standard deviation.

		2019	2020	<i>p</i> values
Number of patients		485	143	
Sex	Male	255 (53%)	93 (65%)	.01
	Female	230 (47%)	50 (35%)	
Age		51.2 \pm 24.8	60.7 \pm 21.5	<.001
Imaging exams	XR	473 (68%)	134 (62%)	.17
	CT	108 (15%)	49 (23%)	.02
	Sonography	118 (17%)	32 (15%)	.6

(36 of 69, 52%) and 2019 (91 of 151, 60%) (*P*<.001). The second most frequent was thorax for 2020 (24 of 69, 35%) and abdomen for 2019 (28 of 151, 18%) (*P*<.001) (Fig.2).

Discussion

Although there was a substantial reduction in the total amount of examinations performed from 2019 to 2020, there was a significant relative increase of patients with positive findings coming from the ED during the COVID-19 lockdown.

A reduction of imaging volumes was expected during COVID-19 pandemic, especially for outpatients [16, 17]. Philips et al found a reduction of 65% of the total number of neuroimaging cases during the COVID-19 vs. pre-COVID-19 period [18]. Furthermore, they also found that the stroke code CT-specific

Table 2. Clinical indications in the selected period of 2020 and 2019; values are in number and percentage.

Clinical Indication	2019	2020	p value
Trauma	285 (59%)	62 (43%)	<.001
Chest	81 (17%)	46 (32%)	<.001
Abdomen	85 (18%)	23 (16%)	.78
Neuro	34 (7%)	12 (8%)	.71

Table 3. Radiological findings of the 3 selected weeks in 2019 and 2020 organized in categories.

Category	Image Findings	2019 n. cases	2020 n. cases
Chest	Consolidation	9	6
	Pleural fluid	5	6
	Consolidation and pleural fluid	3	4
	Ground glass opacities	4	7
	Pulmonary edema ¹	2	1
	Parenchymal lesion ²	2	
Neuro	Hemorrhage	6	1
	Parenchymal lesion ²	1	1
	Stroke		2
Abdomen	Occlusion ³	3	1
	Hydronephrosis ⁴	6	2
	Parenchymal lesion ²	7	2
	Cholecystitis ⁵	3	
	Cholelithiasis ⁶	3	
	Appendicitis ⁷	1	
	Collection/fluid ⁸	3	
	Bleeding	2	
Trauma	Fracture	79	33
	Dislocation	7	3
	Fracture dislocation	3	
	Muscular lesion	1	
	Foreign body	1	
Total		151	69

Criteria: ¹peribronchial cuffing, septal lines; ²neoformation with malignant features; ³dilatation of small bowel >3cm or large bowel >5cm, with or without presence of fluid levels; ⁴dilation >3 mm of the ureter or grade II Hydronephrosis; ⁵gallbladder wall thickening >3 mm; ⁶detection of gallstones; ⁷dilated appendix >6 mm (wall thickening >3mm) or peri-appendiceal fluid collection; ⁸simple fluid present in at least 2 abdomen regions.

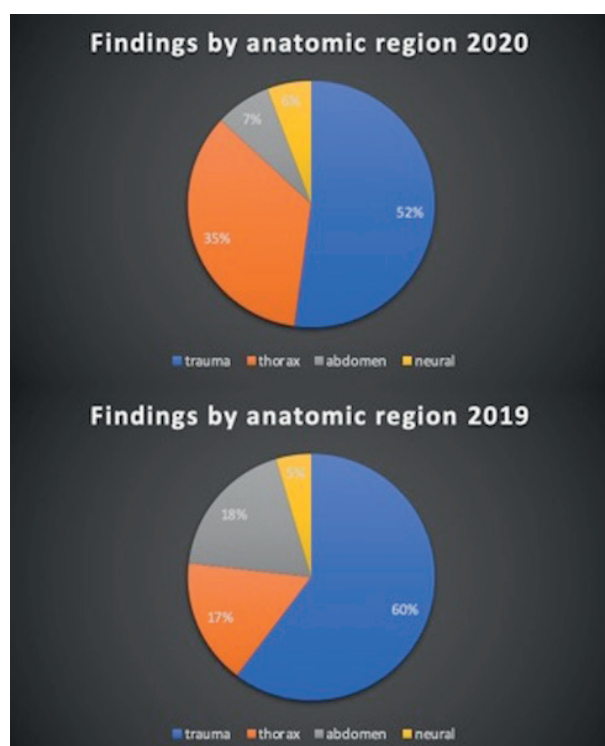


Figure 2. Pie chart showing the percentage of radiological findings by anatomic region in the selected period of 2020 and 2019.

cases declined (59.7%). Houshyar et al reported that ED radiology volumes declined by 32 to 40% during a 2-week time period following the shelter-in-place mandate compared to those of 2019 [15].

Our findings suggest that there is a correlation between the changes in human habits/behaviors as a result of the lockdown, and the changes in the number and outcomes of imaging examinations performed in this period. Lazzerini et al. described a series of pediatric cases where parents reported avoiding accessing hospitals because of fear of infection [19]. The correlation between the pandemic and the fear of people to access medical services has already been reported during the SARS pandemic in 2003 [20]. This potentially explains the overall reduction in examinations observed during the lockdown. Another possible reason for this reduction can be found in a study conducted by Hanna et al [21]. In that study, the authors investigated and defined a class of patients called ED imaging “superusers”. They found that 12% of ED patients consume 50% of all ED imaging services annually. The presence

of this kind of patient might have been decreased in the COVID-19 period.

The fear of people to access hospitals (thought of as contagious places) might not only explain the overall reduction in examinations, but we also hypothesize that the relative increase of positive cases during the lockdown period can be correlated with said fear: given the fear for potential infection, people seem to be waiting for more severe symptoms to occur before seeking hospital care, leading to only people with more serious conditions heading in, thus resulting in a relative increase of positive findings. This increase might also be related to the delay in health care access [19, 22, 23, 24]; since hospitals were prioritizing COVID-19 cases, people had diminished access to immediate care, which might have resulted in more serious conditions being developed.

The sub-analysis, according to both the clinical indications and findings, shows a significant change in the reasons for radiological examinations during the COVID-19 pandemic: there was a relative reduction of both trauma and abdominal instances, and a relative increase of thoracic ones. The reduction of trauma can be related to the diminished chances of injuries due to the lockdown. In a study in a level one trauma center, Christey et al detected a significant reduction (43%) of the overall volume of all injury admissions during the level 4 lock down during COVID-19 pandemic [14]. The relative increase of thoracic clinical indications and findings might be due to the viral pneumonia, even if during the first three weeks of lockdown, only for eight patients the clinical indication was “suspected COVID-19”. These patients had symptoms that could indicate a COVID-19 infection and they were required to wait in isolation for the results of the swab testing, which could take up to three days. While isolated, if necessary, a thoracic XR at the bed of the patient was performed [25, 26]; from these patients, seven tested positive for SARS-CoV-2.

There are some limitations to our study that merit mention. This was a single center study; a more extensive multi-center study should be performed to validate our findings. The clinical indications studied here were derived from the imaging request form and not from the ED clinical chart. Our decision to rate a case as positive was based only on the imaging findings and

not on a clinical evaluation. In spite of these limitations, we believe our study can help the medical field understand how a pandemic, and accompanying lockdown measurements, can impact the epidemiology and types of radiological examinations performed during said period, which is important for a better organization of the ED’s workflow; furthermore, the information presented in our study might lead to a better preparation of community hospitals for readiness to react in case of a secondary peak after the relaxation of the restrictions [27, 28].

Disclosures/Conflict of Interest

- No potential conflict of interest relevant to this article was reported by the authors
- We confirm that this work is original and has not been published elsewhere nor is it currently under consideration for publication elsewhere.
- Publication is approved by all authors and by the responsible authorities where the work was carried out.
- Each author have participated sufficiently in any submission to take public responsibility for its content.
- Written informed consent was obtained from patient, and the study was approved by the ethics committee of the institution.

Abbreviations

COVID-19	Coronavirus Disease of 2019
ED	Emergency Department
XR	Radiograph

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