

ORIGINAL ARTICLE

Impact of COVID-19 pandemic on functioning of cytopathology laboratory: Experience and perspective from an academic centre in New York

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Abstract

COVID-19 has extraordinarily impacted every facet of the health care facilities' operations. Various strategies and policies were implemented promptly to preserve resources, not only to provide medical care to the expected massive numbers of COVID-19 patients, but also to mitigate the contagion spread at the workplace to ensure safety of healthcare workers. All routine, non-essential medical services and procedures were ramped down and workers deemed non-essential were directed to work remotely from home to reduce the number of people at hospital premises and preserve much needed personal protective equipment that were in short supply at the outset of the pandemic. The laboratories did not remain unscathed and were under immense pressure to maintain workplace safety while being operational and provide best patient care with limited resources. In this paper, we share our experience and challenges that we faced in a cytopathology laboratory at a major academic centre in New York, USA during the peak of infection.

KEYWORDS

COVID-19, cytopathology, laboratory, operation, personal protective equipment

1 | INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has created an extraordinary global crisis. The first confirmed case of COVID-19 was detected in New York State (NYS on 1 March and there were 975 cases on the first day of lockdown, 16 March 2020 (<https://www.arcgis.com/apps/opdashboard/index.html#/bda7594740fd40299423467b48e9ecf6>, <https://www.worldometers.info/coronavirus/usa/new-york/>), <https://www1.nyc.gov/site/doh/covid/covid-19-data-archive.page>). From here, NYS became the epicentre of COVID-19 pandemic in the USA with an exponential viral surge resulting in a total of 68 123 cases at the end of March and 356 016 cases on 15 May. NYS has approximately one fifth of all US cases (slightly more than 2 million) of which 284 542 are active and 30 516 patients died of disease as of 9 June 2020.

Numerous public health measures were implemented by the state and local authorities to combat and mitigate the spread of

COVID-19 infection, the cornerstone of public measures being social distancing to reduce person-to-person spread. All academic and community hospitals swiftly came up with new policies and strategies to provide critical care to patients with essential/emergency medical conditions only and suspended all routine outpatient visits, elective surgeries and procedures (starting from 16 March in our hospital). The guidelines were developed promptly to mark essential clinical and research work from non-essential work. The university mobilised their resources to readjust and facilitate the new work routine and all non-essential workers were directed to work remotely from home when practicable. These steps were taken to preserve resources, essential staff and hospital supplies, especially personal protective equipment (PPE) to deal with a tsunami of COVID-19 patients that we were about to face in upcoming weeks.

Our pathology department and cytopathology laboratory continued to function through this challenging situation that was

evolving with continuous revision of institutional policies. We had three goals for this demanding and trying time: (1) maintain safety of staff; (2) provide best patient care with excellent diagnostics; and (3) maintain resident/trainee education.

The guidelines provided by our institution as well as local and national organisations were quickly adopted and implemented for safe specimen handling.¹⁻⁴ Our staff remained available and all services including fine needle aspiration (FNA) and on-site adequacy evaluation continued to be provided during this time. Nonetheless, cancellation of routine patient visits, surgeries and procedures had a direct and substantial impact on the quantity as well as quality of specimens received in our laboratory. In this article, we share and summarise our local experience of COVID-19 pandemic on the everyday functioning of our cytopathology laboratory and the modifications that helped us adapt to a new work environment.

2 | METHODS AND MATERIALS

All cytology specimens, including gynaecological and non-gynaecological, accessioned in our laboratory during the period of *lockdown* 16 March-15 May 2020 were recorded and analysed for specimen types and diagnostic categories. The results were compared with the number of cases accessioned, specimen type and diagnostic categories during the same time period in 2019. Absolute numbers as well as proportions were calculated for each specimen type and diagnostic category. Statistical analysis was performed using χ^2 test and *P* value <.05 was considered statistically significant. In addition, we describe modifications in faculty and staff arrangements and educational activities.

3 | RESULTS

3.1 | Effect on cytology volume

Cytology service has a very limited role in the direct management of patients with COVID-19 acute respiratory disease and we received limited specimens for that issue. Nonetheless, there was a significant reduction in gynaecological as well as non-gynaecological specimen volume during COVID-19 pandemic.

3.2 | Gynaecological specimens

There was 89.5% reduction in gynaecological specimens (*n* = 8128 in 2019, compared to *n* = 853 in 2020) logged in our laboratory. The proportion of non-diagnostic gynaecological specimens was statistically lower in 2020 (0.59%) compared to 2019 (1.45%). A total of 98 (11.5%) gynaecological specimens were diagnosed with squamous epithelial abnormalities during the *lockdown period* in 2020, whereas 741 (9%) cases had this diagnosis during the same time period in 2019. Squamous epithelial abnormalities (AS) included atypical squamous cells of unknown significance (ASCUS), low-grade squamous

intraepithelial lesion (LSIL), high-grade squamous intraepithelial lesion (HSIL) and atypical squamous cells, cannot exclude HSIL (ASC-H). During the *lockdown period* in 2020, 54 cases were diagnosed with ASCUS (6.33% of all specimens), 32 cases with LSIL (3.75%), eight cases with ASC-H (0.94%) and four cases with HSIL (0.47%), while during the similar period in 2019, 319 cases had diagnosis of ASCUS (3.92% of total), 343 diagnosed as LSIL (4.22%), 54 cases with ASC-H (0.66% of total) and 25 cases with HSIL (0.31% of total).

There was a 22% increase in the proportion of atypical squamous abnormalities (including all subtypes of squamous abnormalities) in 2020 when compared to the 2019 proportion; however, this difference in the proportion was not statistically significant. ASCUS, ASC-H and HSIL showed relative increase in proportion (range: 40%-60%) while proportion of LSIL decreased (11%). Only the ASCUS category among squamous abnormalities showed a statistically significant change in proportion. There was only one case of atypical glandular cells in 2020. No further data analysis was done for this category. Figure 1 shows relative distribution of ASCUS, LSIL, ASC-H and HSIL in specimens with squamous epithelial abnormalities only.

3.3 | Non-gynaecological specimens

There was 76% reduction in non-gynaecological cytology specimen volume (519 in 2020 vs 2169 in 2019). Minimum number of daily cases went as low as two in 2020 with a range of two to 29 compared to 2019 with a daily range of 28-85 during the same period. Table 1 shows the number of specimens received during the *lockdown period* in 2020 and corresponding same time in 2019.

3.4 | Specimen types

Decrease in absolute volume for all types of specimen was noted across all specimen types (Table 1); however, change in proportion was variable for different specimen types (Figure 2). Respiratory specimens (included bronchoalveolar lavage [BAL], lung FNA, bronchial wash and brush), effusions, liver and thyroid cytology specimens showed statistically significant changes (*P* < .05) in the proportion whereas changes in the proportion of specimens from pancreas, FNA specimens from sites other than lung, liver and pancreas, urine and cerebrospinal fluid (CSF) were not statistically significant. Few specimen types, particularly effusion cytology (including pleural, peritoneal, pericardial ascitic fluid), showed increase in proportion (90%) and constituted 19% of all specimen types in 2020 compared to 10% in 2019. Notably, no mediastinal lymph node FNA was performed in 2020 during the study period compared to 38 performed during the same time in 2019. The other specimen type that showed increase in proportion was CSF (33% increase) but the increase was not statistically significant. The majority of these CSF specimens came from patients with acute leukaemia and patients with neurological symptoms and those patients were managed on an urgent basis. The

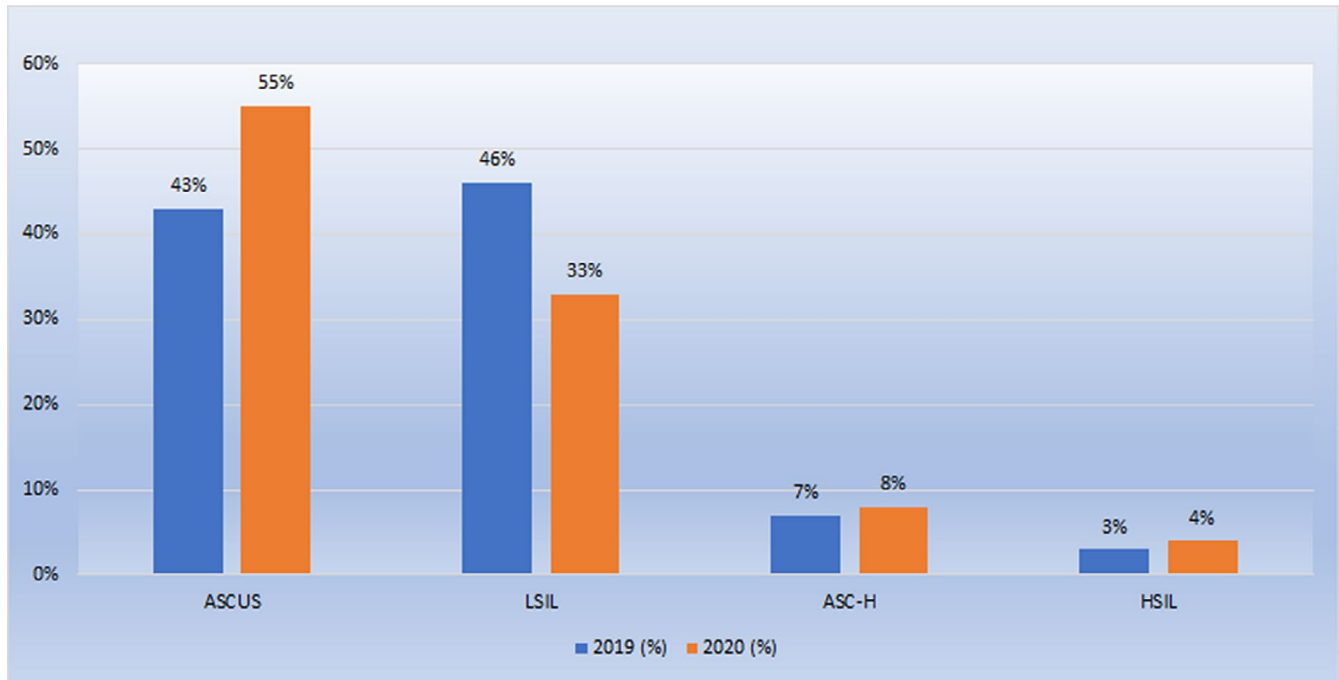


FIGURE 1 Comparison of proportion among different squamous abnormalities in gynaecological specimens with abnormal squamous (AS) cytology diagnosis

TABLE 1 Number of specimen types received during *lockdown period* in 2019 compared to year 2020 for a similar period

Specimen types	2019 (n)	2020 (n)	Percentage change (%) decrease
Respiratory	419	63	85
Effusion	223	100	55
Thyroid	338	54	84
Liver and bile ducts	62	28	54
Pancreas and pancreas ducts	55	10	82
Urine	735	180	75
Aspirates from sites (other than lung, liver and pancreas)	154	33	78
Cerebrospinal fluid	133	44	67
Specimens from miscellaneous sites	50	7	86

proportion of FNA of various sites (other than pancreas, liver and lung) showed a 14% decrease. We separated liver and pancreas FNA from that of other sites as they constitute the majority of FNA specimens in our laboratory. The other sites included FNA of lymph nodes, lesions in salivary glands, stomach and oesophagus, retroperitoneum and aspirates from miscellaneous sites that did not fit the description of sites already specified in our accession system. A total of 33 FNAs were performed on these sites in the study period compared to 154 in 2019. Remarkably, respiratory tract specimens (including BAL, bronchial wash, brush and lung FNA) showed overall decrease in absolute numbers as well as in

proportion (statistically significant, $P < .05$); though BALs showed slight increase in proportion from 10% (2019) to 13% in 2020. Lung FNAs decreased in absolute number (90% reduction) as well as in proportion (56% reduction). The thyroid FNA specimens that represented almost 15% of total specimens in year 2019 showed a decrease in absolute volume ($n = 54$ in 2019 vs $n = 338$ in 2020) as well as in proportion (10% in 2020 vs 16% in 2019).

Figure 3 compares the proportion of diagnostic categories in years 2019 and 2020. Proportion of atypical, suspicious and positive cases increased whereas non-diagnostic and benign categories' proportion decreased. The percentage change in proportion for all diagnostic categories except non-diagnostic was significantly different. The largest increase was noted in the suspicious category (151% increase) followed by positive (61% increase) and atypical (40% increase) categories.

3.5 | Rapid on-site evaluation

Rapid on-site evaluation (ROSE) was performed on 43 (43/519; 8%) specimens during this *lockdown* time, of which 24 (56%) constituted touch imprints of biopsy specimens. The majority of these biopsies were obtained from lung ($n = 11/24$). FNA was performed in 19 cases, with the most common site being pancreas ($n = 4$), followed by liver ($n = 3$). Only one paediatric thyroid FNA with ROSE was performed during this time. The rest of the FNA specimens were obtained from various sites including abdomen, mediastinum and soft tissue. In comparison, a total of 305 (15%) non-thyroid cytology specimens (including FNA and touch imprints) received ROSE in year 2019 and the difference in proportion was statistically significant ($P = .0002$). No request for superficial FNAs was received during this time period.

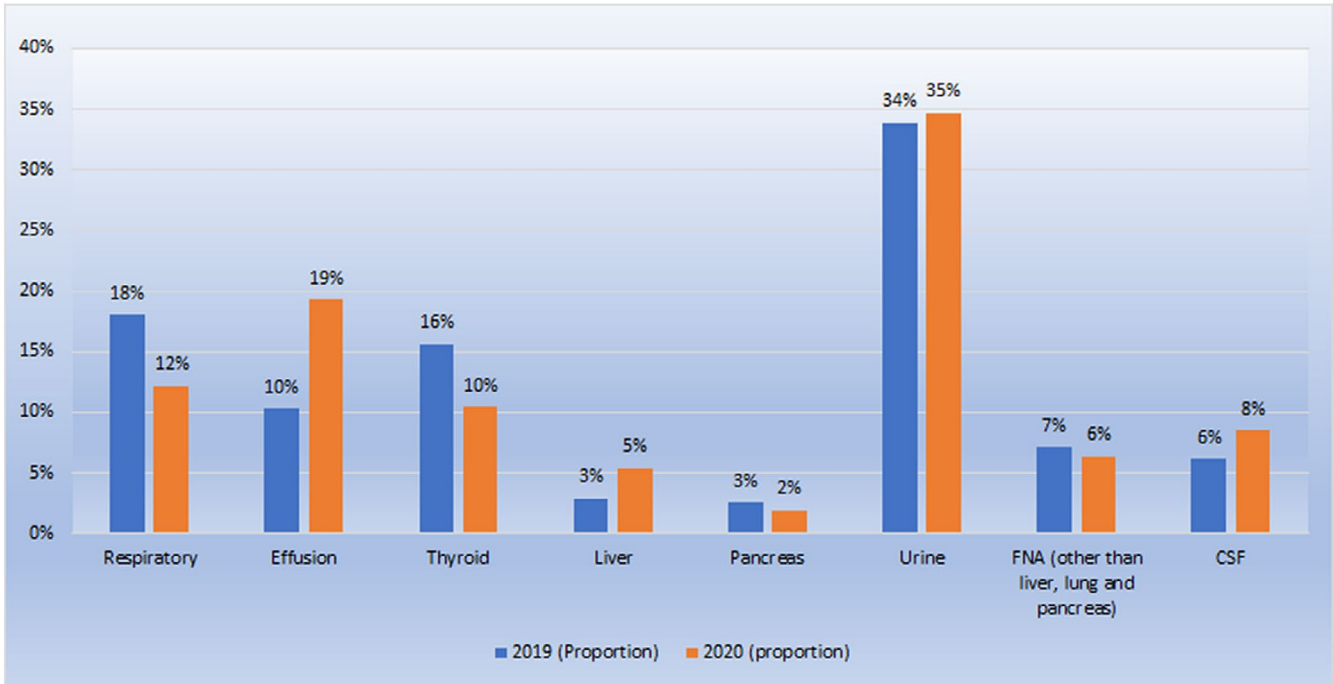


FIGURE 2 Change in proportion of different specimen subtypes

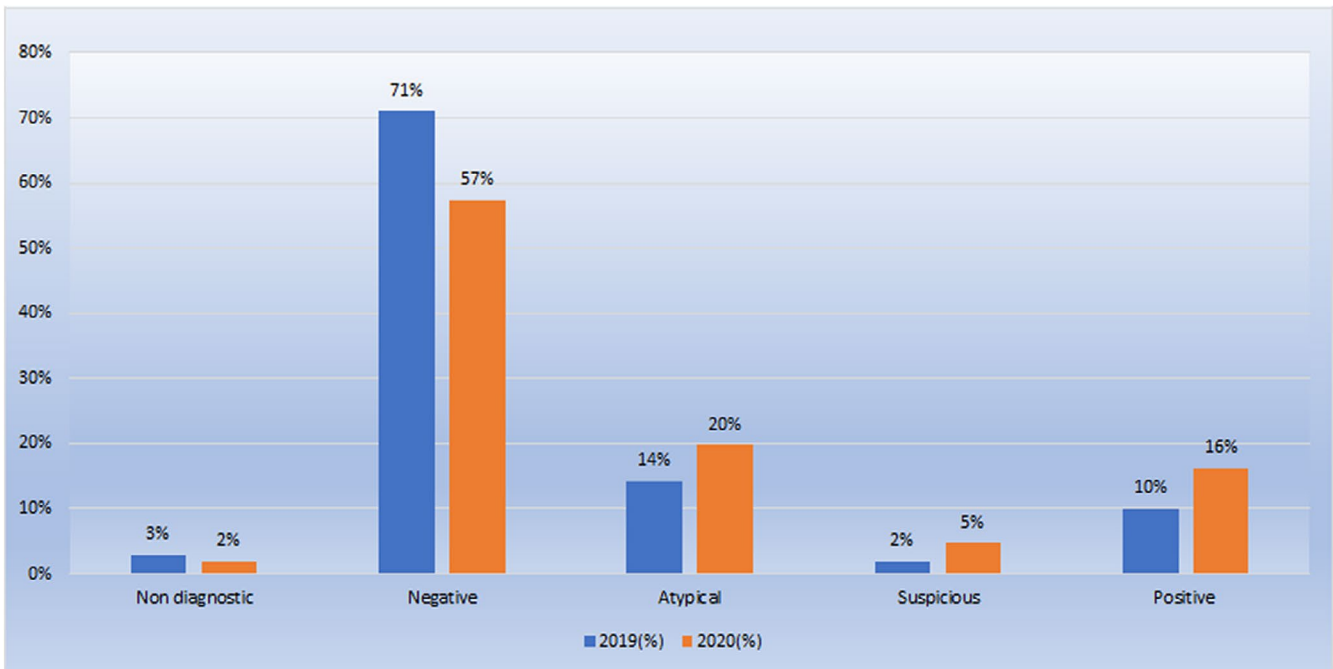


FIGURE 3 Comparison of proportion of diagnostic categories between 2019 and 2020 for non-gynaecological specimens

3.6 | Cytology specimens from patients who tested positive for COVID-19 infection

During the study period (16 March-15 May 2020), we received 31 specimens from 26 COVID-19 positive patients and approximately one-quarter of all these specimens were diagnosed with malignancy (n = 7). The most common specimen from COVID-19 infected patients

was pleural fluid (n = 9) and half of them (4/9) were found to be malignant, two patients had pre-existing cancer metastatic to pleural cavity (breast and Mullerian primary), one with prior history of large cell lymphoma, one patient had newly diagnosed small cell carcinoma. Notably, BAL fluid was received only from three COVID-19 infected patients while none of these patients had lung or mediastinal lymph node FNA.

3.7 | Impact on faculty and staff

3.7.1 | Faculty

In our laboratory, three cytopathologists (CP) cover daily cytology services, following a 3-day cycle, designated as CP1, CP2 and CP3 days. CP on CP1 day receives gynaecological specimens, BAL, urine, and effusion cytology specimens; and performs superficial FNAs. In addition, they provide backup for all ROSE performed by cytotechnologists present on-site. All endoscopic ultrasound and endobronchial ultrasound FNA ROSE are reviewed remotely via telecytopathology. The CP on the second day of service receives all FNAs and touch imprints, CSFs and pancreato-biliary specimens. The third day of sign-out is utilised to sign-out all cases pending for additional ancillary studies and issue addenda. During this *lockdown* period, faculty staffing was consolidated and reduced to only one CP present on-site to review and sign-out cases, so each CP signed out every third day. Any cases pending for the day were handed over to the CP covering the next day, therefore CPs shared all specimens seamlessly. We cancelled our on-campus daily intradepartmental consensus conference and immediately switched to daily remote video conferencing.

3.7.2 | Cytotechnologists

In our laboratory, ROSE is provided by cytotechnologists (CT) on-site while CP is available as backup for challenging cases. We continued to provide ROSE during this time for FNAs and for biopsy touch imprints, though the number of requests was significantly reduced, as expected. Our laboratory had adequate, albeit limited, PPE. All CTs were provided with one N95 mask and surgical masks/face shields to cover the N95 masks for prolonged use. All universal precautions were followed as during pre-COVID-19 time. Our CTs prepared air-dried smears for on-site evaluation and triaged the specimens based on the findings. Telecytopathology was utilised as needed. Alcohol-fixed slides, liquid-based preparations (ThinPrep) and cell blocks were prepared in the laboratory in biosafety hoods following universal precautions. All staff involved in specimen processing and handling were provided with N95 masks and all specimens were prepared in the biosafety hood while following universal precautions. All CTs stations were spaced out in the laboratory to follow required physical/social distancing. CTs volunteered to be redeployed to other parts of the hospital. These CTs were predominantly involved in specimen shipping from collection site to the testing facility, helping with supply chain in the hospital, and assisted in morgue activities.

3.7.3 | Education

The residents on cytopathology rotation sign-out on a one-on-one basis with their assigned attending during daily sign-outs. However, this sign-out model was not feasible as 6-foot distance at a dual-headed microscope could not be maintained. Dual-headed

microscopes allow for approximately 2-foot distance. We substituted direct teaching with microscopes with virtual platforms for daily sign-out. Residents could preview the cases and sign-out with a pathologist utilising live audio-video streaming. In addition, residents were also guided to our in-house education resources available on our cytology-dedicated shared drive as well as web-based education provided by American Society of Cytopathology and United States and Canada Academy of Pathology.

3.7.4 | Virtual platform

We adopted a password protected virtual platform (Zoom) for daily consensus conference, resident teaching, and all other educational and administrative meetings and conferences. The university provided guidelines to maintain privacy and security. The quality of images and live streaming of audio and video was of excellent quality with no interruption or delay. This virtual platform was also highly helpful for our daily consensus conference. We were able to achieve consensus in the majority of cases except rare cases where they were left for personal slide review by CP on sign-out schedule for the day.

4 | DISCUSSION

We encountered an unparalleled and challenging situation during this pandemic. It has impacted all specialties of medicine, some of the effects are broad spectrum affecting all specialties while others are unique to each specialty. In this paper, we have reviewed the scale of COVID-19 impact on cytopathology volume and specimen types, staffing and trainee's education at our institution.

4.1 | Work environment

We faced several unprecedented challenges during this pandemic. The most notable ones included the maintenance of best patient care while providing a safe work environment for both staff and faculty. The cytology team suffered significant stress and anxiety due to the uncertainty of the crisis combined with limited access to PPE and mandatory requirement to maintain social distancing. Numerous operational steps were taken at the beginning and were continuously updated based on the guidelines issued by national and regional organisations as the situation unfolded.¹⁻⁴ Assurance of workplace safety for the entire staff, particularly cytotechnologists and laboratory staff working in specimen accessioning and processing areas, was of paramount importance. Our institution implemented strategies to preserve PPEs by suspending routine patient care and the majority of research work. A centralised database was set up to keep account of all PPEs available and then distribute them to the different departments depending upon their risk of exposure. PPE was limited but fortunately our entire staff was able to get at least one N95, surgical masks, face shields and disposable laboratory coats while

gloves remained available as before. All employees were video-educated regarding appropriate donning and doffing of PPEs. Later on, the institution provided surgical masks to everyone entering the hospital buildings and mandated all employees to wear masks in hospital premises. Limited guarded entrances to the hospital assisted with the compliance for uniform mask policy. The rationing of PPEs was also eased gradually as more were made available with time. All these steps helped with physical health and alleviated the anxiety to a significant extent.

If obtaining adequate PPE was a big challenge, following social distancing was no less. In New York, where space is premium, it can be an extremely daunting task to provide adequate physical distancing (6 feet as recommended) in the building. Many strategies were developed to help with social distancing at institutional as well as departmental level. Non-essential workers were allowed to work remotely from home, reducing the overall number of people present in the building at a time. However, this was not a solution for our laboratory as all personnel in our laboratory were considered essential and were directed to report to work every day.⁵⁻⁷ Our department allowed all subspecialties to tailor the staffing and functioning based on daily/current volume and adjust accordingly. Considering the volume was almost three quarters down, we all agreed that one CP could comfortably handle the daily sign-out work. All CPs on academic time were directed to work remotely. Consolidating the cytology faculty with only one CP available on-site made other CPs' offices available for use by the other staff with reassignment of workstations to CTs. Some of the CTs were deployed to hospital specimen collection areas and helped in transporting specimens to the lab, therefore not required to be present in the lab. Some of the other difficulties, although not major but problematic nevertheless, encountered in the lab included lack of service work for equipment maintenance as vendors refused to physically visit the laboratory. There were few interviews scheduled for future hiring and some were cancelled, while others were performed virtually via Zoom.

4.2 | Patient care

Having one CP on-site helped with social distancing but gave us another challenge of maintaining continuity of patient care while preserving the fair schedule for CPs. The cases were shared by all CPs covering the block service and handed over daily at the end of the day to the CP on a sign-out schedule for the next day. Handing over the cases is not routinely done in our cytopathology laboratory and we relied heavily on encrypted e-mail communications and virtual platforms. All challenging cases that could potentially be pending for the next day were reviewed over virtual platforms by CPs on service and a consensus was obtained for preliminary diagnosis and strategy for additional ancillary studies, whenever needed. In addition, an encrypted email including details about all cases pending for additional studies and addenda was sent to all three CPs on sign-out schedule and the cytology laboratory director at the end of each day. The sharing of information, including preliminary diagnosis with clinical history, was immensely helpful

to maintain the best patient care without significantly extending the turnaround time while minimising the CP's physical presence in hospital premises. Although the overall volume of daily logged cases was strikingly low, the cases were more challenging either due to the limited quantity or quality of cellular material. The majority of these specimens were obtained from patients with urgent medical needs, most common being oncological issues that required immediate attention.

4.3 | Laboratory volume

Our laboratory lost almost 76% of its volume compared to the 2019 for a similar time span. However, the effect on proportion of cases was not uniform across different specimen types. In this study, we included the change in absolute numbers as well as the proportion of cases, as we expected the latter to be more informative of the impact of COVID-19 on cytology specimens, therefore reflecting the prompt effects of changes in clinical practice due to the pandemic. We established that the effect on absolute numbers (reduction) was uniform, whereas the effect on proportion was variable as more specimens from patients with urgent care needs, mostly oncological diagnosis, continued to receive medical care at our hospital. Among specimen types, the most remarkable change was noticed on body fluids (including pleural, peritoneal, pericardial and ascites fluid) as their proportion almost doubled compared to that of 2019, similar to a report published by a cytology laboratory from Italy.⁸ This laboratory also reported statistically significant increase in urine, breast and lymph node specimens. In our lab, urine specimens showed marginal increase of 1% (statistically non-significant) while breast (0.8% and 1% in years 2020 and 2019 respectively) and lymph nodes (1.5% and 2.2% in 2020 and 2019, respectively) decreased in proportion, but this decrease was not statistically significant. The other specimen type that showed an increased proportion was CSF specimens from leukaemia patients, but this increase was not statistically significant. The specimens from the respiratory system were also reduced except for BALs, which we continued to receive from transplant patients as our hospital is an advanced transplant care centre. Thyroid FNAs, which is one of the most prevalent specimens in our laboratory, got significantly reduced not only in absolute numbers but also in proportion as the majority of the thyroid nodules do not need immediate attention.

Among diagnostic categories, malignant cases showed a 61% increase. One of the most remarkable increases was noted in the suspicious category (almost 150% increase), which indicates the challenges that we faced. These specimens were obtained from patients with clinical suspicion of malignancy and these specimens lacked either qualitative or quantitative criteria to reach a definitive diagnosis. All suspicious cases were reviewed by multiple cytopathologists virtually as well in office when available, highlighting the difficulty in achieving a definitive diagnosis. Similarly, the 40% increase in the atypical category highlights the fact that, even though specimen volume went down, cases were

more than ever challenging and difficult to diagnose. Our findings of increased proportion of malignant diagnosis are similar to the paper published from an Italian cytology laboratory.⁸ Among gynaecological specimens, all diagnostic categories under squamous abnormalities showed an increase in proportion of except LSIL that showed a decrease. It would be difficult to determine the exact reason but we speculate a combination of factors. Firstly, patients with high-risk factors were continued to be seen in the doctor's office compared to patients with low or no risk factors till the last of allowed routine office visits. Secondly, the increased diagnosis of ASCUS reflects the effect of absence of in-person intradepartmental consensus meetings. We noticed that there was a tendency to have a lower threshold for imparting atypical diagnosis on virtual platforms as this experience was entirely new for all the cytopathologists. This effect on atypical categories was noticed in gynaecological specimens as well as non-gynaecological specimens, as discussed above.

We did not receive requests for superficial FNAs during this time and received a smaller number of requests for ROSE ($n = 43$). We received 31 cytology specimens from patients who tested positive for COVID-19, of which our CTs provided ROSE on three cases: one touch imprint of a mediastinal mass biopsy; two FNAs, one from pancreas and one from a gastrohepatic lymph node. The cytology specimens from COVID-19 positive patients were low as the number of invasive diagnostic procedures performed on these patients were kept low to avoid aerosol generation and risk of exposure. We received three BAL specimens from COVID-19 positive patients with acute respiratory distress syndrome. Our CTs were required to report to their lab manager before providing ROSE for patients who tested positive for COVID-19. We were fortunate that none of our staff reported contracting COVID-19 infection while at work.

4.4 | Virtual platforms

Virtual platforms played an essential role helping us in managing cases.⁹ We conducted a daily intradepartmental consensus conference on a virtual platform that was open to all CPs, CTs and trainees. We also used a virtual platform for our daily sign-out with residents. This virtual platform enabled us to live stream the slide review with the attending present remotely or in the resident's room or in the call room. Many virtual platforms were available and we decided to use Zoom due to easy availability and excellent audio-video quality without any delays in streaming. The slide review was live streamed to remote sites using screen share function while projecting slides through camera on our office desktop screen. All CPs have already installed cameras on each of their microscopes and are connected to the computer screen. All these steps helped us maintain social distance, reduce the risk of exposure while at the hospital or during travel to work, as public transport is one of the preferred ways of commuting in New York. Moreover, travel itself was difficult due to reduced public transportation.

4.5 | Education

The COVID-19 pandemic had a significant adverse effect on trainee's education. In anatomic/clinical pathology residency training, residents typically receive only 3 months of cytopathology training as part of their core curriculum, following Accreditation Council for Graduate Medical Education guidelines. During the *lockdown* status of 2 months, we had two residents who rotated in cytology. One month is a significant duration for cytology training as it makes one third of their total training time and limited specimen volume and specimen range can have negative impact on education and confidence in diagnosis.

The COVID-19 pandemic has changed the traditional ways of medical practice, many changes were short-term, but some other changes will persist in the future. It required staff deployment and workflow to be redesigned and reorganised according to each hospital's situation. Web-based applications/platforms played an essential role in medicine, not only for patient care but also for medical education and teaching. Our community came together to rapidly adapt to this new normal in a very short period of time. Now that we have adjusted to a *new normal* and practices are slowly returning to pre-COVID time, we still continue to take measures to prevent infection spread. Uniform mask policy at work and virtual platforms will be our go-to option to maintain social distancing. There is always a learning curve to any new crisis and we will continue to evolve as we will face new challenges until a permanent cure and/or a vaccine are found. This is an opportunity to make our operations more robust and technology-friendly while providing secure patient care with excellent quality.

To conclude, this pandemic started with heightened anxiety for everyone; however, looking back over the last several months, we were able to maintain work continuity and provide timely essential services with utmost quality. In this paper, we have shared our laboratory's operational experience during the peak of infection in New York and report the diverse ways that we explored to provide best patient care and continuous education to our trainees.

CONFLICT OF INTEREST

None of the authors have any relevant conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are not publicly available due to privacy restrictions.

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