
Pooja Patel, MD
Rheann Brownstone, MD
Brianne Cruickshank, MD
Connor Garagan, BScN
Daria Manos, MD
Daniel French, MD, MASc
Alison Wallace, MD, PhD
Madelaine Plourde, MD, MSc

Background: The effect of the COVID-19 pandemic on the diagnosis and management of lung cancer in Canada is not fully understood. We sought to quantify the provincial volume of diagnostic imaging, thoracic surgeon referrals, time to surgery after referral, and pathologic staging for curative surgery in the context of the pandemic, as well as explore the effect of a pooled patient model, which was implemented to prioritize surgeries for lung cancer and mitigate the effects of the pandemic.

Methods: We conducted a retrospective cohort study of patients who underwent diagnostic imaging in Nova Scotia and were subsequently referred to a thoracic surgeon at the province’s only tertiary care centre for surgical management of their primary lung cancer before (Mar. 1, 2019, to Feb. 29, 2020) and during (Mar. 1, 2020, to Feb. 28, 2021) the COVID-19 pandemic. We conducted a survey to capture the patient and surgeon experience with a pooled patient model of managing surgical oncology cases.

Results: Compared with the pre-COVID-19 period, the overall volume of chest radiography and chest computed tomography decreased by 30.9% ($p < 0.001$) and 18.7% ($p = 0.002$), respectively, in the COVID-19 period. Thoracic surgeon referrals, operative approach, extent of resection, length of hospital stay, and pathologic staging did not significantly differ. Time from referral to surgery was significantly shorter during the COVID-19 period (mean 196.8 d v. 157.9 d, $p = 0.04$). A pooled patient approach contributed to positive patient satisfaction.

Conclusion: The COVID-19 pandemic was associated with reductions in rates of diagnostic imaging and referrals to thoracic surgeons for management of pulmonary cancer. A pooled patient model was used to mitigate the effects of the pandemic on lung cancer management and was positively received by patients. An extended study period is needed to determine the full effect of this redistribution of resources.

Contexte : L’effet de la pandémie de COVID-19 sur le diagnostic et la prise en charge du cancer du poumon au Canada n’est pas entièrement compris. Nous avons voulu connaître le volume provincial d’épreuves d’imagerie diagnostique et de demandes de consultation en chirurgie thoracique, de même que l’intervalle entre les consultations et les chirurgies et le stade de la maladie justiciable d’une chirurgie à visée curative dans le contexte de la pandémie, en plus d’explorer l’effet d’un modèle de cas groupés pour établir l’ordre de priorité des chirurgies pour le cancer du poumon et atténuer les effets de la pandémie.


Résultats : Comparativement à la période pré-COVID-19, le volume global des radiographies pulmonaires et des tomodensitométries thoraciques a diminué de 30.9% ($p < 0.001$) et de 18.7% ($p = 0.002$), respectivement, durant la période de COVID-19. Les consultations en chirurgie thoracique, l’approche chirurgicale, l’ampleur de la résection, la durée du séjour hospitalier et la stadification de la maladie n’ont pas différé significativement. L’intervalle entre les consultations et les chirurgies a été significativement plus bref durant la période de COVID-19 (moyenne 196.8 j c. 157.9 j, $p = 0.04$). Le modèle de priorisation des cas groupés a contribué favorablement à la satisfaction des malades.
Lung cancer is the leading global cause of cancer-related deaths among both males and females.1 In Canada, lung cancer has the highest cancer mortality; Nova Scotia has one of the highest rates of stage IV disease at the time of diagnosis in the country.2,3 To optimize the diagnosis and management of lung cancer in Nova Scotia, all suspected cases of lung cancer are referred to a single group of thoracic surgeons at the Queen Elizabeth II Hospital in Halifax. The province (encompassing 1 million people) falls under a single health authority for adult medicine, and all lung cancer referrals are triaged to a single centre, which provides a unique opportunity to study the management of this disease at a provincial level in a publicly funded health care system. This is unique in comparison with other provinces, where several centres manage the same disease.

Despite longstanding evidence for the benefits of screening programs for lung cancer, lung cancer screening remains limited in Canada. Pilot programs are being developed but most screening for lung cancer occurs on an ad hoc basis. Until recently, Nova Scotia did not have a formal screening program for lung cancer, and diagnosis was primarily when findings on chest radiography prompted further investigation with chest computed tomography (CT) and subsequent referral to the single-centre group of thoracic surgeons.

The COVID-19 pandemic, declared in March 2020, resulted in the redistribution of health care providers and resources to prioritize management of acute care inpatients. This, in turn, led to delays in outpatient care, including the diagnosis and treatment of lung cancer. A study by Lang and colleagues4 found a 72% decrease in the annual volume of low-dose CT scans during the pandemic. In the United Kingdom, models of the effects of the pandemic on detection of lung cancer estimated an increase of 5.8%–6% in deaths after 5 years of diagnosis, secondary to the pandemic.5

Overall, Nova Scotia saw few cases of COVID-19 thanks to the implementation of and compliance with strict public health measures. In anticipation of high numbers of cases, an overwhelmed hospital system, and operating room closures, thoracic surgeons developed a strategy to address potential delays in the management of lung cancer. The approach was to pool patients with the next available surgeon. In this model, patients are scheduled for surgery with the next available surgeon in the pool, meaning that the surgeon who initially consulted with the patient may not be the one performing the surgery. This approach is often implemented to ensure timely access to surgery and efficient utilization of surgical resources. It allows for flexibility in scheduling and can help reduce wait times for patients. This practice model is the standard of care at only 2 thoracic surgery centres in Canada.

The implications of the COVID-19 pandemic on the diagnosis and management of lung cancer in Canada are not fully understood. The primary aim of this study was to assess the monthly volume of diagnostic imaging (chest radiography and chest CT scans) conducted at every hospital in Nova Scotia from March 2019 to March 2021. Secondary objectives included evaluating the quantity of referrals to the single centre that serves the whole province for lung cancer. In addition, for each patient referred for surgical management of lung cancer, we sought to determine their surgical–pathological stage of cancer using the eighth edition of the tumour, lymph node, metastasis (TNM) staging system.6 Furthermore, we sought to explore the patient and surgeon experience with the pooled patient model of managing surgical oncology cases.

**METHODS**

A retrospective cohort study was completed. We defined the pre-COVID-19 period as Mar. 1, 2019, to Feb. 29, 2020, and the COVID-19 period as Mar. 1, 2020, to Feb. 28, 2021. We excluded patients younger than 18 years.

We reviewed Nova Scotia’s diagnostic imaging database for all chest radiographic and CT images completed within the study period. We classified the period of images based on the date the images were acquired. We compared the monthly number of images.

We reviewed our thoracic surgery referral database, which captures all referrals to the sole institution that manages lung cancer in Nova Scotia, to review the monthly number of referrals to thoracic surgery and patient wait times. We categorized patients as referred in the pre-COVID-19 or COVID-19 periods based on the date of referral and included them if they underwent resection for primary lung cancer. We computed wait time as the number of days from the date of referral to the date of surgery.

At the beginning of the COVID-19 period, the pooled patient model was adopted. Before this time, during the pre-COVID-19 period, the traditional single-surgeon approach was used. To assess the effect of pooling patients, we conducted a telephone survey of the patients who were...
pooled and operated on between Mar. 20, 2020, and July 1, 2020, as well as the 4 thoracic surgeons involved in the new triage system. A thoracic surgery nurse conducted a 4-question survey, which took no more than 10 minutes. The surgeons also provided written feedback about their experience.

**Statistical analysis**

We employed standard descriptive statistics to characterize the sample, which included calculating the mean and standard deviation for continuous variables and frequencies and percentages for categorical variables. To assess the significance of our findings, we used relevant statistical tests, including the $\chi^2$ test for categorical data and the 2-sample $t$ test or nonparametric Wilcoxon test for continuous variables. We defined significance as a $p$ value of less than 0.05.

**Ethics approval**

This study was approved by the Nova Scotia Health Research Ethics Board (no. 1027678).

**RESULTS**

Compared with the pre-COVID-19 period, the total number of chest radiographs decreased by 30.9% ($p < 0.001$), equivalent to 44906 fewer radiographs, of which 14974 were conducted in the emergency department ($p < 0.001$) and 29930 were outpatient radiographs ($p < 0.001$) (Figure 1). The overall volume of chest CT scans also decreased by 18.7% ($p = 0.002$), equivalent to 4727 fewer scans, of which 132 were conducted in the emergency department ($p = 0.4$) and 4595 were outpatient scans ($p = 0.001$) (Figure 2). The COVID-19 period had 71 (6.5%) fewer thoracic surgeon referrals ($p = 0.5$) than the pre-COVID-19 period (Figure 3).

Among patients who underwent surgery for primary lung cancer, patient characteristics — including age, body mass index, sex, and smoking status — did not differ significantly by period (Table 1). Operative approach and extent of resection did not differ between time periods (Table 2). Time from referral to surgery was significantly shorter during the COVID-19 period at 157.9 days, compared with 196.8 days in the pre-COVID-19 period ($p = 0.04$). The postoperative length of stay did not differ between time periods (Table 2), nor did pathologic staging (Table 3).

In our survey ($n = 40$), despite consenting to surgery with the surgeon the patient met in clinic, most patients (92%) indicated that they were not informed that the surgeon they initially met during their clinic visit would not be the one performing their surgery. Most patients (83%) had the opportunity to meet the new surgeon before their scheduled surgery. Despite the change in surgeons, all patients reported that they did not perceive any negative effect on the care they received. However, when asked about their recommendations for other patients, the responses were evenly split, with half suggesting scheduling with the first available surgeon and the remaining 50% recommending waiting for the surgeon with whom they originally consulted. In the comments section, some patients shared their
Fig. 2. Monthly volume of chest computed tomography (CT) scans in Nova Scotia from March 2019 to March 2021.

Fig. 3. Monthly referrals to thoracic surgeons at Nova Scotia’s only tertiary care centre in the pre-COVID-19 (March 2019 to February 2020) and COVID-19 (March 2020 to February 2021) periods.
perspectives. One patient expressed, “I got the surgery done, and that’s the main thing,” while another remarked, “I felt well taken care of.” Overall, patients expressed relief at being able to have their surgery completed during the COVID-19 period. The surgeons at the centre initially had a divided opinion on pursuing a pooled patient model. After its implementation during the COVID-19 period, most surgeons changed to advocate for this approach to enhance surgical efficiency, reduce wait times, and improve surgeon well-being through flexible scheduling.

**DISCUSSION**

Health care providers altered their practice in various ways during the COVID-19 pandemic. One of the effects of these changes was a decrease in cancer detection, cancer management visits, and cancer surgeries.\(^7\) During the peak of the pandemic, an estimated 38% of cancer surgeries were cancelled worldwide.\(^8\) Patt and colleagues\(^7\) found that, in April 2020, screening for lung cancer was 56% lower than the previous year and lung cancer encounters decreased by 40%–50%.\(^7\) In the UK, it was predicted that these delays would increase deaths from lung cancers by as much as 5.3% after 5 years.\(^5\)

A retrospective cohort study found that lung cancer diagnoses declined by 34.7% from 2019 to 2020.\(^9\) Despite this, the first appointment with a lung cancer specialist was not significantly delayed (72% were seen within the 14-day target in 2020, compared with 69% in 2019).\(^9\) There was a significant delay for receiving lung cancer surgery in 2020 (76 d in 2020 v. 64 d in 2019, \(p = 0.04\)).\(^9\) Definitive treatment was provided to the same number of patients in each year (85% in 2019 v. 82% in 2020).\(^9\) Interestingly, this study found a 14% increase in radiotherapy given with curative intent in early-stage disease and an associated 13% decrease in surgical resections during the pandemic.\(^9\)

In summary, the COVID-19 pandemic was associated with both a decrease in lung cancer diagnoses in 2020, compared with 2019.\(^10\) Results differed by sex, with a decrease among males (–9.6%) but not females (+3.1%).\(^10\) In addition, there was a decrease in diagnosis of stage I disease (19.8% v. 12.9%) with an associated increase in diagnosis of stage III disease (12.7% v. 19.1%).\(^10\) Surgery decreased from 28.7% to 21.5% and chemotherapy increased from 17.6% to 34.3%.\(^10\)

In summary, the COVID-19 pandemic was associated with both a decrease in diagnosis of lung cancer and a delay in diagnosis, as seen by the later stage at diagnosis. Practice and treatment choices also changed, likely in part owing to decreased availability of operating room time, as seen by the increase in treatment with radiotherapy and chemotherapy over surgery. At our institution, we identified a significant decrease in volume of diagnostic imaging, including both chest radiographs and chest CTs, as well as a subsequent decrease in referrals to thoracic surgeons during the

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**Table 1. Characteristics of patients who underwent surgical resection for primary lung cancer**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pre-COVID-19</th>
<th>COVID-19</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr, mean</td>
<td>71.1</td>
<td>71.1</td>
<td>1.0</td>
</tr>
<tr>
<td>BMI, mean</td>
<td>29.3</td>
<td>28.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Sex, female</td>
<td>102 (55.1)</td>
<td>105 (62.1)</td>
<td>0.2</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>Current smoker</td>
<td>61 (33.0)</td>
<td>56 (33.1)</td>
<td></td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>107 (57.8)</td>
<td>92 (54.4)</td>
<td></td>
</tr>
<tr>
<td>Never smoker</td>
<td>17 (9.2)</td>
<td>17 (10.1)</td>
<td></td>
</tr>
<tr>
<td>Pack-year history</td>
<td>39.0</td>
<td>37.9</td>
<td>0.7</td>
</tr>
</tbody>
</table>

BMI = body mass index. *Unless indicated otherwise.

**Table 2. Operative characteristics of patients who underwent surgical resection for primary lung cancer**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pre-COVID-19</th>
<th>COVID-19</th>
<th>Total</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative approach</td>
<td></td>
<td></td>
<td></td>
<td>0.79</td>
</tr>
<tr>
<td>Open</td>
<td>16 (8.6)</td>
<td>16 (9.5)</td>
<td>32 (9.0)</td>
<td></td>
</tr>
<tr>
<td>VATS</td>
<td>169 (91.4)</td>
<td>153 (90.5)</td>
<td>322 (91.0)</td>
<td></td>
</tr>
<tr>
<td>Extent of resection</td>
<td></td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td>Sublobar</td>
<td>37 (20.0)</td>
<td>25 (14.8)</td>
<td>62 (17.5)</td>
<td></td>
</tr>
<tr>
<td>Lobectomy</td>
<td>144 (77.8)</td>
<td>139 (82.2)</td>
<td>283 (79.9)</td>
<td></td>
</tr>
<tr>
<td>Pneumonectomy</td>
<td>4 (2.2)</td>
<td>5 (3.0)</td>
<td>9 (2.5)</td>
<td></td>
</tr>
<tr>
<td>Time from referral to surgery, d, mean</td>
<td>196.8</td>
<td>157.8</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>LOS, d</td>
<td>5.6</td>
<td>5.3</td>
<td>0.74</td>
<td></td>
</tr>
</tbody>
</table>

LOS = length of stay; VATS = video-assisted thoracoscopic surgery. *Unless indicated otherwise.

**Table 3. Pathologic stage of patients who underwent surgical resection for primary lung cancer**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Pre-COVID-19</th>
<th>COVID-19</th>
<th>Total</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA1</td>
<td>38 (20.5)</td>
<td>26 (15.4)</td>
<td>64</td>
<td>0.35</td>
</tr>
<tr>
<td>IA2</td>
<td>37 (20.2)</td>
<td>35 (20.7)</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>IA3</td>
<td>23 (12.4)</td>
<td>27 (16.0)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>IB</td>
<td>31 (16.8)</td>
<td>32 (18.9)</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>IIA</td>
<td>11 (5.9)</td>
<td>9 (5.3)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>IIB</td>
<td>18 (9.7)</td>
<td>20 (11.8)</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>IIIA</td>
<td>23 (12.4)</td>
<td>13 (7.7)</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>IIIB</td>
<td>2 (0.5)</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>IVA</td>
<td>2 (1.1)</td>
<td>3 (1.8)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>IVB</td>
<td>0</td>
<td>4 (2.4)</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

*Unless indicated otherwise.
COVID-19 period. We attribute these findings to decreased access to primary care and emergency departments, as well as the implementation of mandatory isolation periods within the province during this period. Studies with an extended study period (3–5 yr) are needed to determine the full effect of redistribution of resources. We would expect to see decreased survival and upstaging at the time of presentation despite expanding diagnostic and therapeutic options.

The pathologic staging of patients in our cohort remained similar in both time periods. The volume of patients with stage IIA lung cancer was unexpectedly high in both periods and may be a reflection of inadequate preoperative staging, given limited access to endobronchial ultrasonography. Resection for stage IIIB and IVA/B was for tissue diagnosis due to inconclusive prior biopsies or for aborted operations due to metastasis identified on frozen section intraoperatively.

Our institution had significant reductions in wait times for curative-intent surgery for lung cancer during the COVID-19 pandemic. We attribute this reduction to the prioritization of cancer operations in the context of a comparable number of overall operative days. Although wait times may be perceived as long, the initial time to referral represented an initial consultation with the surgeon and not necessarily an appointment for consenting to surgery. For instance, patients with mixed-density nodules required follow-up chest CTs before an ultimate decision to pursue operative treatment could be made, while those with stage 3A cancer would have delayed surgery for induction chemoradiation. Furthermore, by adopting a pooled patient model, surgeon and operating room time was optimized. Patients were triaged according to guidance from the American College of Surgery. Patients categorized into priority bands 2 and 3 were automatically scheduled with the next available surgeon. A systematic review confirmed that single-entry models were associated with a reduction in time from referral to consultation. The primary aim of this approach is to establish a continuous and uninterrupted connection between the patient and the surgeon. This continuity of care can enhance the overall patient experience, as the assigned surgeon becomes intimately familiar with the patient’s medical history, individual preferences, and specific health care needs.

Each of these models comes with its own set of advantages. Pooling patients ensures swift access to surgery, potentially reducing patient wait times. This model also optimizes the allocation of surgical resources by guaranteeing that surgeries are performed by available, skilled surgeons. Furthermore, it provides flexibility in scheduling, which enables patients to be matched with surgeons based on their availability.

On the other hand, the model of assigning a surgeon to follow the patient’s journey offers unique benefits. It ensures the continuity of care under the guidance of a single surgeon who possesses in-depth knowledge of the patient’s case. This approach fosters a strong patient–surgeon relationship based on trust and familiarity. Moreover, it enhances communication and enables personalized care, as the assigned surgeon possesses a comprehensive understanding of the patient’s medical history and individual needs.

Overall, we found that, although patients were generally not aware of the change in surgeons, they did not perceive a negative effect on the care they received. The divided responses regarding recommendations suggest a level of uncertainty or differing preferences among patients regarding the choice of surgeon. Marshall and colleagues determined that the next-available-surgeon distribution policy reduced wait times for consultation. They also found that, although some patients wished to see certain surgeons, others preferred to see the first available surgeon. A systematic review confirmed that single-entry models were associated with a reduction in time from referral to consultation. The single-entry model consists of a centralized intake or a pooled referral system in coordination with a centralized approach to triaging these referrals. Importantly, all of the studies reported positive patient satisfaction with single-entry models.

Limitations

We suspect that our short time frame for analysis of staging did not capture the delayed effect of decreased diagnostic imaging, and further analysis over subsequent years is required.
CONCLUSION

The COVID-19 pandemic led to significant reductions in diagnostic imaging and subsequent referrals to thoracic surgeons for the assessment of lung cancer. For those patients needing curative-intent surgery, adopting a pooled patient model meant that surgical treatment could be promptly delivered. We found that the provincial COVID-19 policy safeguarded limited health care resources and allowed the centre to continue to perform surgeries. Given the high rates of lung cancer in Nova Scotia and poor outcomes, advocacy to prioritize lung cancer surgery resulted in patients receiving treatment within an expedited time frame. Furthermore, the pooled patient approach contributed to positive patient satisfaction. However, the long-term outcomes have yet to be explored, including the effect on care received by patients with benign conditions, not included in this analysis. The choice between the 2 predominant models of surgical oncology care should consider various factors, including the nature of the surgical oncology practice, the availability of resources, patient volume, and the specific requirements and preferences of both patients and health care providers. Each approach has its distinct merits, and the decision should be grounded in what is deemed most suitable and feasible within the particular health care context. In our single-payer, publicly funded health care system with limited resources, the pooled patient model had advantages in terms of expediting cancer care. For those opposed to a pooled patient model in oncology, prioritization forces uncomfortable choices, but it is important to be fair and equitable, both to patients and surgeons.

Affiliations: From the Department of Surgery, Dalhousie University, Halifax, N.S. (Patel, Brownstone, Cruickshank, Garagan, French, Wallace, Plourde); the Department of Radiology, Dalhousie University, Halifax, N.S. (Manos); the Department of Pathology, Dalhousie University, Halifax, N.S. (Wallace).

Competing interests: Daniel French reports honoraria from AstraZeneca; he is a member of the Nova Scotia Lung Association Medical Advisory Board. No other competing interests were declared.

Contributors: Pooja Patel, Daria Manos, Alison Wallace, and Madelaine Plourde contributed to the conception and design of the work. Rheann Brownstone, Brianne Cruickshank, and Connor Garagan contributed to data acquisition. Daniel French contributed to data analysis and interpretation. Pooja Patel drafted the manuscript. All of the authors revised it critically for important intellectual content, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

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