Wait times in the management of non–small cell lung carcinoma before, during and after regionalization of lung cancer care: a high-resolution analysis

Saad Shakeel, MPH
Mankeeran Dhanoa, MD
Omar Khan, MSc
Pooya Dibajnia, MD
Noori Akhtar-Danesh, PhD
Abdollah Behzadi, MD, MBA

The abstract was accepted for presentation at the Canadian Surgery Forum (Sept. 7, 2019).

Accepted May 1, 2020

Correspondence to:
A. Behzadi
Credit Valley Hospital
2200 Eglinton Avenue West
Mississauga ON L5M 2N1
abdollah.behzadi@thp.ca

DOI: 10.1503/cjs.013319

Background: Timeliness can have a substantial effect on treatment outcomes, prognosis and quality of life for patients with lung cancer. We sought to evaluate changes in wait times for patients with non–small cell lung carcinoma (NSCLC) and to identify bottlenecks in cancer care.

Methods: We included patients who received treatment with curative intent or palliative treatment for NSCLC, diagnosed through mediastinal staging by a thoracic surgeon. Data were collected from 3 cohorts over 3 time periods: before the regionalization of lung cancer care (2005–2007, C1), immediately postregionalization (2011–2013, C2) and 5 years after regionalization (2016–2017, C3). Total wait time and delays along treatment pathways were compared across cohorts using multivariate Cox proportionality models.

Results: Our total sample size was 299 patients. Overall, there was no significant difference in total wait time among the 3 cohorts. However, wait time from symptom onset to first physician visit significantly increased in C3 compared with C2 (hazard ratio [HR] 0.41, $p < 0.01$) and C1 (HR 0.43, $p < 0.01$). Time from first physician visit to computed tomography (CT) scan significantly decreased in C3 compared with C2 (HR 1.54, $p < 0.01$). Time from abnormal CT scan to first surgeon visit also significantly decreased in C2 (HR 1.43, $p < 0.01$) and C3 (HR 4.47, $p < 0.01$) compared with C1, and between C3 and C2 (HR 2.67, $p < 0.01$). In contrast, time from first surgeon visit to completion of staging significantly increased in C2 (HR 0.36, $p < 0.01$) and C3 (HR 0.24, $p < 0.01$) compared with C1, as well as between C3 and C2 (HR 0.60, $p < 0.01$). Time to first treatment after completion of staging was significantly shorter for C3 than C1 (HR 1.58, $p < 0.01$).

Conclusion: Trends toward a reduction in wait time are evident 5 years after the regionalization of lung cancer care, primarily led by shorter wait times for CT scans and thoracic surgeon consults. However, wait times can further be reduced by addressing delays in staging completion and patient and provider education to identify the early signs of NSCLC.

Contexte : La rapidité d'intervention peut avoir un effet considérable sur l'issue du traitement, le pronostic et la qualité de vie des patients atteints d'un cancer du poumon. Nous avons voulu évaluer les changements des temps d'attente des patients ayant un carcinome pulmonaire non à petites cellules et recenser les obstacles aux soins oncologiques.

Méthodes : Nous avons inclus des patients ayant reçu un traitement curatif ou palliatif pour un carcinome pulmonaire non à petites cellules diagnostiqué par stadification de lésions médiastinales par un chirurgien thoracique. Les données ont été recueillies auprès de 3 cohortes, à 3 moments : avant la régionalisation des soins oncologiques (2005–2007; C1), immédiatement après la régionalisation (2011–2013; C2) et 5 ans après la régionalisation (2016–2017; C3). Le temps d'attente total et les délais au cours du processus de traitement des cohortes ont été comparés au moyen de modèles à risques proportionnels de Cox multivariés.

Résultats : Au total, l'échantillon comptait 299 patients. Dans l'ensemble, aucune différence statistiquement significative n'a été observée entre les 3 cohortes pour ce qui est du temps d'attente total. Cependant, la C3 présentait un temps d'attente entre l'apparition des symptômes et la première consultation médicale significativement plus long que la C2 (rapport de risque [RR] 0,41; $p < 0,01$) et que la C1 (RR 0,43; $p < 0,01$). Le temps d'attente entre la première consultation médicale et la tomodensitométrie

(TDM) était par contre significativement plus court dans la C3 que dans la C2 (RR 1,54; $p < 0,01$). Le délai entre l'obtention d'un résultat anormal à la TDM et la première consultation chirurgicale était également significativement moindre dans la C2 (RR 1,43; $p < 0,01$) et dans la C3 (RR 4,47; $p < 0,01$) que dans la C1, mais aussi entre la C3 et la C2 (RR 2,67; $p < 0,01$). À l'inverse, le temps écoulé entre la première consultation chirurgicale et la fin de la stadification était significativement plus long dans la C2 (RR 0,36; $p < 0,01$) et la C3 (RR 0,24; $p < 0,01$) que dans la C1; il en était également ainsi entre la C3 et la C2 (RR 0,60; $p < 0,01$). Enfin, le délai entre le premier traitement et la fin de la stadification était significativement plus court dans la C3 que dans la C1 (RR 1,58; $p < 0,01$).

Conclusion : Cinq ans après la régionalisation des soins oncologiques, on peut observer une réduction des temps d'attente, principalement une diminution du temps d'attente pour une TDM ou une consultation chirurgicale. Les temps d'attente pourraient être davantage raccourcis par une réduction des délais dans la stadification, ainsi que par la sensibilisation des patients et des fournisseurs de soins à l'égard de la reconnaissance des signes précoces de carcinome pulmonaire non à petites cellules.

Lung cancer is a significant health care burden in Canada, representing an estimated 14% of all diagnosed cancers in 2017.[1] Timely access to care is recognized as an important facet of high-quality care.[2] For lung cancer in particular, timeliness can have a substantial effect on treatment outcomes, prognosis and quality of life; thus, shorter time intervals between evaluation, diagnosis and management of patients with suspected lung cancer is recommended by clinical practice guidelines.[3–9] Wait times can be affected by patient-, provider- and system-specific factors. The identification of bottlenecks along the care pathway, from symptom onset to treatment, can improve timely access to care for the management of lung cancer.

In Ontario, the regionalization of thoracic surgery formally started in 2004 to better manage patient volume by improving access and expediting patient management, to facilitate multidisciplinary care and to improve patient outcomes. This was achieved through the establishment of regionalized cancer centres, which promoted streamlined referrals from primary care providers. For a hospital to be designated as a regional centre for thoracic cancer surgery, the hospital needed to possess the following: a minimum of 3 certified thoracic surgeons, 24-hour operating room availability, a clinical thoracic unit and access to an interdisciplinary oncology team.[10] By 2010, nearly all (94%) lung resections were consolidated to 15 designated high-volume hospitals, defined by an annual target of > 150 lung resections for non–small cell lung carcinoma (NSCLC). Studies suggest that regionalization has resulted in improvements in length of hospital stay[10,11] but an increase in travel time,[12] with conflicting evidence suggesting improved patient outcomes.[10–13] There is, however, limited literature regarding the effect of regionalization on overall wait time in the management of NSCLC, as well as the identification of bottlenecks in the care pathway. Our objective was to evaluate the effect of regionalization on the management of NSCLC by comparing wait times before regionalization, immediately after regionalization and 5 years after regionalization. Total wait time (i.e., from symptom onset to treatment and management) was divided into systematic segments along the care pathway to identify bottlenecks in care across the 3 cohorts.

Methodology

Study design and patient selection

We conducted a retrospective review, evaluating records for all patients who underwent mediastinal staging for diagnoses of NSCLC by a thoracic surgeon through cervical mediastinoscopy or endobronchial ultrasonography. We selected the cervical mediastinoscopy as the entry criteria to the study to preferentially capture patients who were eligible for surgical resection. We included only patients with pathologically confirmed NSCLC. We excluded patients who underwent invasive mediastinal staging for diagnoses other than NSCLC. We also excluded patients with NSCLC who did not receive mediastinal staging as they had a stage IV disease diagnosed by other modalities, had comorbidities that prohibited medical intervention or declined investigations. As the focus of our study was evaluating the wait times for treatment and management of NSCLC, we excluded patients who did not go through the subsequent work-up process or who declined treatment or management. We excluded patients with incomplete data, those with other primary cancers or those who died before the start of treatment. By focusing on patients who underwent cervical mediastinoscopy and endobronchial ultrasonography, we included those who might have been considered for definitive therapy or needed pathological proof of N2 disease, thereby ensuring inclusion of a large number of patients who obtained treatment via different pathways. The treatment and management modalities included surgery, chemotherapy, radiation therapy or any form of palliative care therapy for management of NSCLC.

We used the practice of 1 surgeon who initially operated in a low-volume hospital and subsequently in a high-volume hospital to control for practice-associated variation. The high-volume hospital was previously a low-volume thoracic centre that was then designated as a regional thoracic cancer surgery centre after recruiting thoracic oncologists. We included cohorts from 3 time periods relative to the regionalization of lung cancer care: before regionalization (January 2005 to April 2007; C1), immediately after regionalization (January 2011 to April 2013; C2) and 5 years after regionalization (January 2016 to December 2017; C3). We included C2 to show the organizational challenges and associated effect on wait times immediately after the implementation of regionalization. Patients in the first cohort received care in the low-volume hospital, and the patients in the second and third cohorts received care in the high-volume hospital.

Data collection

We manually extracted data on patient and disease characteristics, treatment and care pathways from hospital charts and outpatient office records. Baseline characteristics included age, sex, initial presenting symptom(s) that led to the diagnosis of NSCLC, medical specialty of first physician contact, tumour pathology, cancer stage and the type of initial oncologic treatment.

To evaluate wait times in the management of NSCLC, we constructed a timeline of care (Figure 1). We recorded 6 time points for each patient: self-reported onset of symptoms that led to the diagnosis of NSCLC, first visit to the presenting physician, first computed tomography (CT) imaging of the chest (or first diagnostic imaging that identified the chest lesion, for asymptomatic patients with incidental radiologic findings), first consult with thoracic surgeon, completion of cancer staging for initiation of the first oncologic treatment and initiation of first oncologic treatment (surgery, chemotherapy, radiation or palliative care). Asymptomatic patients with incidental radiologic patients did not have data for symptom onset and first physician visit. We used these time points to calculate wait times between sequential care segments, namely symptom onset to first physician visit (WT1), physician visit to CT scan (WT2), CT scan to first surgeon consult (WT3), first surgeon visit to staging completion (WT4), and staging completion to first treatment (WT5). We also calculated the total wait time, defined as the time from symptom onset to delivery of first oncologic treatment. Completion of cancer staging was defined as the final diagnostic imaging or pathological investigation before a decision was made for the first oncologic treatment. Patients were included in the analysis if at least 4 of the 6 time points were available in the charts.

Statistical analysis

We conducted univariate analysis of categorical variables using a χ^2 test. We compared total wait times and interval delays across cohorts using multivariate Cox proportionality models with a forward stepwise approach, including patient-, tumour-, treatment- and provider-specific factors, added in this order. We used Stata 9.4 for Windows for statistical analysis.

Ethics approval

This study was approved by the Institutional Review Board of Scarborough Hospital and the Trillium Research Ethics Board.

Results

Our study included 299 patients (n = 102, 101 and 96 for cohorts 1–3, respectively). Table 1 presents the distribution of patient-, procedure- and provider-specific factors by cohort, along with a comparison of total wait times and segment-specific wait times. The median total wait time before regionalization (C1) was 122 (interquartile range [IQR] 95.5–216) days,

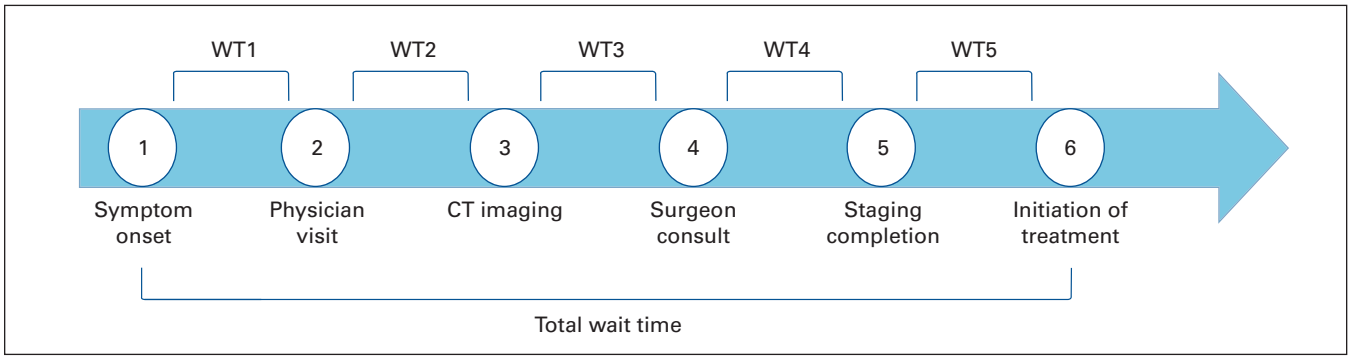

Fig. 1. Overview of wait time intervals in the care pathway for non–small cell lung carcinoma. CT = computed tomography, WT = wait time.

148 (IQR 105–230) days immediately after regionalization (C2) and 139.5 (95–206) days 5 years after regionalization (C3). There were also differences between the cohorts in median time from onset of symptoms to first physician visit, CT scan to first consult with the thoracic surgeon, consult to completion of staging and staging completion to treatment initiation. In addition, the median wait time for positron emission tomography (PET) scan was 14.5 days after the surgeon visit for patients in C2 and 20 days for C3. Significant differences in univariate analysis were observed between cohorts in tumour, node and metastasis (TNM) stage of presentation, the type of biopsy performed, specialty of first physician, incidental findings and the type of definitive treatment. Therefore, these variables were included in the adjusted analysis.

Table 2, Table 3, Table 4 and Table 5 present the results of Cox proportionality models, and Figure 2 presents a comparison of median interval wait times among the 3 cohorts, highlighting the statistically significant differences based on multivariate analysis. The final model included cohort, patient age, sex, disease stage, first physician, treatment type and whether the tumour was an incidental finding. Increasing patient age was associated with a significantly longer time from CT scan to first surgeon visit, first surgeon visit to completion of staging and total wait time, but was associated with a significantly shorter time from symptom onset to first physician visit. Female patients were significantly more likely to wait longer than male patients from symptom onset to first physician visit. Patients who were in stage II and IV at presentation had a significantly higher likelihood of shorter wait time from abnormal CT scan to first surgeon visit than patients in stage I. Patients with stage II disease also had a significantly higher likelihood of shorter total wait time than patients with stage I disease. If the patients had first contact with the emergency department versus a general physician, they had significantly higher likelihood of experiencing shorter total wait times. Treatment did not affect total wait time or any of the wait time segments.

There were no significant differences in total wait time for patients in the postregionalization cohorts compared with the preregionalization cohort. However, within the postregionalization period, the total wait time was significantly shorter for patients in C3 compared with C2. The time from symptom onset to first physician visit significantly increased in the 5-year postregionalization period compared with immediately postregionalization and preregionalization. There were no significant differences between preregionalization and immediately postregionalization in time to symptom onset to first physician visit. The time from first physician visit to initial CT scan was significantly shorter for patients in C3 compared with C2. The time from CT scan to first surgeon visit significantly decreased over time; this segment was shortest for patients in C3 compared with C2 and C1, and was significantly shorter for C2 compared with C1. In contrast, the time between first surgeon visit and completion of staging significantly increased over time; this segment was longest for patients in C3 compared with C2 and C1, and was significantly longer for C2 patients compared with C1. Lastly, the time from staging completion to first treatment or management modality was significantly shorter in the cohort from 5 years after regionalization compared with the cohort before regionalization.

Table 1. Univariate comparison of wait times and patient-, procedure- and provider-specific factors, by cohort

Variable	No (%) of patients* Cohort 1 *n* = 102	Cohort 2 *n* = 101	Cohort 3 *n* = 96	*p* value
Age, mean ± SD, yr	69 ±10	68 ± 9	68 ± 10	—
Sex				
Male	58 (56.9)	45 (44.6)	45 (46.9)	0.177
Female	44 (43.1)	56 (55.4)	51 (53.1)	
Biopsy type				
CM	102 (100.0)	85 (84.2)	61 (63.5)	< 0.001
EBUS	0 (0)	16 (15.8)	35 (36.5)	
TNM stage				
I	33 (32.4)	43 (42.6)	36 (37.5)	< 0.001
II	15 (14.7)	19 (18.8)	14 (14.6)	
III	34 (33.3)	29 (28.7)	22 (22.9)	
IV	20 (19.6)	10 (9.9)	24 (25.0)	
First contact				
GP	58 (56.9)	60 (59.4)	72 (75.0)	0.017
ED/ respirologist/ walk-in/ other	44 (43.1)	41 (40.6)	24 (25.0)	
Definitive treatment				
Surgery	65 (63.7)	68 (67.3)	55 (57.3)	< 0.001
Chemoradiation	37 (36.3)	33 (32.7)	41 (42.7)	
Incidental				
Yes	33 (32.4)	47 (46.5)	25 (26.0)	< 0.001
No	69 (67.6)	54 (53.5)	71 (74.0)	
Median wait time (IQR), d†				
WT 1	4 (0–16)	2 (0–21)	28.5 (0–83)	—
WT 2	24 (6–39)	11 (0–27)	13 (5–27)	—
WT 3	51 (28–95)	36 (17–85)	14 (7–26)	—
WT 4	9 (7–17)	21 (14–34)	28.5 (16–47)	—
WT 5	31.5 (21–50.5)	32.5 (19–48)	29 (15–41)	—
Total wait time	122 (95.5–216)	148 (105–230)	139.5 (95–206)	—

CM = cervical mediastinoscopy, CT = computed tomography, EBUS = endobronchial ultrasound, ED = emergency department, GP = general practitioner, IQR = interquartile range, TNM = tumour, node, metastasis, WT = wait time.

*Unless indicated otherwise.

†WT1 = symptom onset to first physician visit, WT2 = physician visit to CT scan, WT3 = CT scan to first surgeon consult, WT4 = first surgeon visit to staging completion, WT5 staging completion to first treatment.

Table 2. Cox proportionality model for comparison of wait time, all cohorts

	Hazard ratio (95% CI)*					
Variable	WT1	WT2	WT3	WT4	WT5	Total wait time
Time period						
Cohort 1 (reference)						
Cohort 2	0.86 (0.54–1.37)	0.62 (0.35–1.10)	1.38 (1.00–1.91)†	0.34 (0.24–0.47)†	1.26 (0.90–1.75)	0.81 (0.58–1.12)
Cohort 3	0.39 (0.25–0.61)†	0.95 (0.57–1.59)	4.16 (2.97–5.83)†	0.24 (0.17–0.33)†	1.59 (1.16–2.19)†	1.09 (0.80–1.52)
Age	1.20 (1.00–1.44)†	0.86 (0.70–1.05)	0.78 (0.69–0.89)†	0.92 (0.80–1.06)	0.72 (0.64–0.83)†	0.75 (0.66–0.87)†
Sex						
Male (reference)						
Female	0.69 (0.47–1.00)	1.01 (0.70–1.46)	1.03 (0.80–1.34)	0.88 (0.67–1.14)	1.24 (0.96–1.61)	1.01 (0.77–1.32)
TNM stage						
Stage I (reference)						
Stage II	1.72 (0.95–3.11)	1.03 (0.60–1.76)	1.60 (1.09–2.34)†	1.03 (0.70–1.50)	1.0 (0.68–1.47)	1.50 (1.01–2.22)†
Stage III	1.13 (0.59–2.13)	1.39 (0.79–2.47)	1.22 (0.83–1.79)	1.09 (0.74–1.63)	1.12 (0.76–1.66)	1.09 (0.73–1.64)
Stage IV	1.23 (0.56–2.69)	1.00 (0.47–2.16)	1.69 (1.03–2.79)†	1.45 (0.88–2.40)	1.20 (0.72–2.00)	1.25 (0.75–2.11)
First physician						
GP (reference)						
ED/ respirologist/ walk-in/ other	1.04 (0.66–1.63)	1.33 (0.85–2.07)	1.00 (0.77–1.31)	0.91 (0.69–1.20)	1.24 (0.95–1.62)	1.62 (1.21–2.17)†
Definitive treatment						
Surgery (reference)						
Chemoradiation	1.26 (0.66–2.40)	1.32 (0.71–2.45)	1.47 (0.99–2.18)	1.03 (0.69–1.55)	0.97 (0.65–1.45)	1.47 (0.96–2.23)
Incidental finding	—					
No (reference)						
Yes	—	1.34 (0.84–2.13)	0.65 (0.48–0.86)†	1.04 (0.77–1.40)	0.88 (0.66–1.16)	

CI = confidence interval, GP = general practitioner; ED = emergency department, TNM = tumour, node, metastasis, WT = wait time.
*WT1 = symptom onset to first physician visit, WT2 = physician visit to CT scan, WT3 = CT scan to first surgeon consult, WT4 = first surgeon visit to staging completion, WT5 staging completion to first treatment.
†Significant at $p \leq 0.05$

Table 3. Cox proportionality model for comparison of wait time, cohort 3 versus cohort 1 (reference group)

	Hazard ratio (95% CI)*					
Variable	WT1	WT2	WT3	WT4	WT5	Total wait time
Time period						
Cohort 1 (reference)						
Cohort 3	0.41 (0.26–0.66)†	0.88 (0.51–1.50)	4.47 (3.10–6.46)†	0.24 (0.17–0.34)†	1.58 (1.14–2.19)†	1.14 (0.81–1.60)
Age	1.18 (0.95–1.46)	0.91 (0.71–1.16)	0.81 (0.69–0.94)†	0.91 (0.77–1.07)	0.74 (0.64–0.86)†	0.78 (0.67–0.91)†
Sex						
Male (reference)						
Female	0.74 (0.47–1.15)	0.80 (0.50–1.28)	1.19 (0.88–1.62)	0.86 (0.63–1.18)	1.13 (0.83–1.54)	1.00 (0.73–1.37)
TNM stage						
Stage I (reference)						
Stage II	1.75 (0.89–3.41)	1.0 (0.51–1.98)	1.80 (1.13–2.88)†	0.97 (0.61–1.55)	0.82 (0.51–1.33)	1.58 (0.98–2.55)
Stage III	1.83 (0.83–4.07)	1.04 (0.46–2.35)	1.82 (1.10–2.98)†	0.92 (0.57–1.49)	0.97 (0.59–1.59)	1.12 (0.66–1.88)
Stage IV	1.79 (0.69–4.65)	0.77 (0.27–2.22)	2.04 (1.14–3.67)†	1.05 (0.59–1.87)	0.87 (0.48–1.57)	1.19 (0.65–2.21)
First Physician						
GP (reference)						
ED/ respirologist/walk-in/ other	1.11 (0.63–1.95)	0.96 (0.50–1.84)	0.89 (0.64–1.24)	1.17 (0.85–1.62)	1.29 (0.92–1.81)	1.66 (1.16–2.37)†
Definitive treatment						
Surgery (reference)						
Chemoradiation	0.85 (0.38–1.89)	1.65 (0.69–3.95)	1.16 (0.72–1.89)	1.39 (0.85–2.27)	1.23 (0.76–1.99)	1.51 (0.89–2.54)
Incidental finding						
No (reference)						
Yes	—	1.57 (0.87–2.83)	0.68 (0.48–0.98)†	1.19 (0.84–1.70)	0.93 (0.66–1.32)	1.13 (0.77–1.66)

CI = confidence interval, GP = general practitioner; ED = emergency department, TNM = tumour, node, metastasis, WT = wait time.
*WT1 = symptom onset to first physician visit, WT2 = physician visit to CT scan, WT3 = CT scan to first surgeon consult, WT4 = first surgeon visit to staging completion, WT5 staging completion to first treatment.
†Significant at $p \leq 0.05$

Table 4. Cox Proportionality model for comparison of wait time, cohort 3 versus cohort 2 (reference group)

	Hazard ratio (95% CI)*					
Variable	WT1	WT2	WT3	WT4	WT5	Total wait time
Time period						
Cohort 2 (reference)						
Cohort 3	0.43 (0.25–0.71)†	1.54 (1.02–2.31)†	2.67 (1.85–3.85)†	0.60 (0.43–0.84)†	1.20 (0.86–1.67)	1.55 (1.05–2.28)†
Age	1.20 (0.96–1.49)	0.88 (0.70–1.10)	0.82 (0.69–0.98)†	0.89 (0.75–1.07)	0.79 (0.67–0.93)†	0.75 (0.61–0.92)†
Sex						
Male (reference)						
Female	0.76 (0.48–1.18)	0.97 (0.65–1.46)	0.90 (0.65–1.24)	0.90 (0.64–1.25)	1.14 (0.83–1.57)	0.91 (0.64–1.29)
TNM stage						
Stage I (reference)						
Stage II	2.08 (1.01–4.28)†	1.03 (0.58–1.82)	1.55 (0.98–2.45)	1.20 (0.76–1.90)	1.29 (0.82–2.02)	1.71 (1.06–2.74)†
Stage III	0.94 (0.42–2.11)	1.13 (0.60–2.14)	1.06 (0.64–1.77)	0.76 (0.44–1.30)	1.19 (0.69–2.05)	0.93 (0.53–1.63)
Stage IV	1.23 (0.47–3.22)	0.84 (0.36–1.94)	1.71 (0.90–3.28)	1.72 (0.94–3.16)	1.76 (0.91–3.42)	1.43 (0.69–2.99)
First physician						
GP (reference)						
ED/ respirologist/walk-in/other	1.43 (0.82–2.49)	1.39 (0.86–2.24)	0.96 (0.68–1.35)	0.70 (0.48–1.01)	1.18 (0.83–1.67)	1.93 (1.30–2.89)
Definitive treatment						
Surgery (reference)						
Chemoradiation	1.35 (0.58–3.13)	1.46 (0.75–2.87)	1.74 (1.03–2.96)†	1.19 (0.70–2.02)	1.06 (0.60–1.86)	1.72 (0.93–3.17)
Incidental finding						
No (reference)						
Yes	—	1.16 (0.71–1.90)	0.68 (0.47–0.98)	0.91 (0.62–1.33)	0.83 (0.58–1.18)	1.29 (0.83–2.02)

CI = confidence interval, GP = general practitioner; ED = emergency department, TNM = tumour, node, metastasis, WT = wait time.
*WT1 = symptom onset to first physician visit, WT2 = physician visit to CT scan, WT3 = CT scan to first surgeon consult, WT4 = first surgeon visit to staging completion, WT5 staging completion to first treatment.
†Significant at $p \leq 0.05$

Table 5. Cox proportionality model for comparison of wait time, cohort 2 versus cohort 1 (reference group)

	Hazard ratio (95% CI)*					
Variable	WT1	WT2	WT3	WT4	WT5	Total wait time
Time period	0.94 (0.59–1.48)	0.71 (0.39–1.29)	1.43 (1.02–2.01)†	0.36 (0.26–0.52)†	1.19 (0.84–1.67)	0.81 (0.58–1.12)
Cohort 1 (reference)						
Cohort 2						
Age	1.31 (1.04–1.66)†	0.87 (0.65–1.18)	0.73 (0.62–0.85)†	0.95 (0.79–1.14)	0.65 (0.55–0.78)†	0.76 (0.64–0.90)†
Sex						
Male (reference)						
Female	0.66 (0.41–1.08)	1.61 (0.93–2.78)	1.02 (0.73–1.42)	0.83 (0.59–1.16)	1.42 (1.02–1.98)†	1.14 (0.81–1.60)
TNM stage						
Stage I (reference)						
Stage II	1.40 (0.65–3.02)	1.21 (0.53–2.77)	1.40 (0.87–2.26)	0.90 (0.56–1.47)	0.93 (0.56–1.54)	1.19 (0.72–1.97)
Stage III	0.83 (0.43–1.63)	3.13 (1.31–7.50)†	1.02 (0.67–1.57)	1.38 (0.86–2.20)	1.18 (0.75–1.86)	1.15 (0.73–1.81)
Stage IV	0.79 (0.31–2.03)	2.33 (0.70–7.68)	1.61 (0.84–3.08)	1.48 (0.71–3.06)	1.21 (0.60–2.42)	1.11 (0.57–2.15)
First physician						
GP (reference)						
ED/ respirologist/ walk-in/ other	0.78 (0.46–1.34)	2.13 (1.10–4.13)†	1.16 (0.84–1.61)	0.84 (0.59–1.18)	1.19 (0.86–1.65)	1.39 (1.00–1.95)
Definitive treatment						
Surgery (reference)						
Chemoradiation	1.74 (0.83–3.65)	1.02 (0.42–2.46)	1.45 (0.92–2.30)	0.84 (0.51–1.40)	0.70 (0.43–1.14)	1.34 (0.83–2.16)
Incidental finding						
No (reference)						
Yes	–	1.09 (0.55–2.16)	0.55 (0.39–0.79)†	1.15 (0.79–1.68)	0.92 (0.65–1.31)	0.69 (0.47–1.01)

CI = confidence interval, GP = general practitioner; ED = emergency department, TNM = tumour, node, metastasis, WT = wait time.
*WT1 = symptom onset to first physician visit, WT2 = physician visit to CT scan, WT3 = CT scan to first surgeon consult, WT4 = first surgeon visit to staging completion, WT5 staging completion to first treatment.
†Significant at $p \leq 0.05$

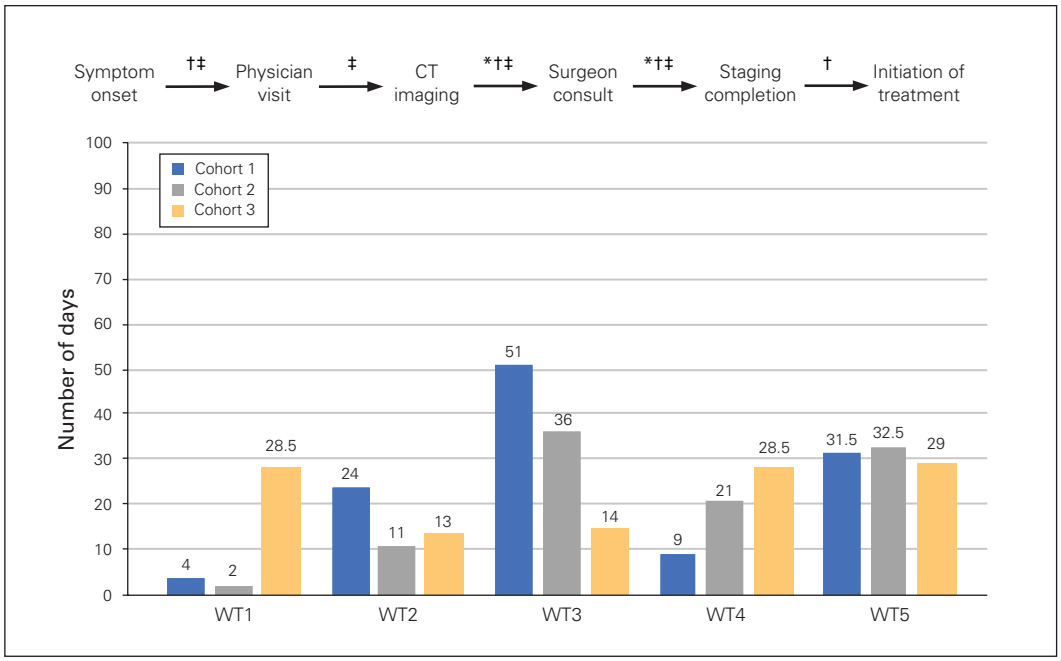

Fig. 2. Comparison of median wait times between cohorts 1 and 2. WT1 = symptom onset to first physician visit, WT2 = physician visit to computed tomography (CT) scan, WT3 = CT scan to first surgeon consult, WT4 = first surgeon visit to staging completion, WT5 staging completion to first treatment. *$p < 0.05$ cohort 1 v. cohort 2. †$p < 0.05$ cohort 1 v. cohort 3. ‡ $p < 0.05$ cohort 2 v. cohort 3.

Discussion

Our results provide insight into the shifting nature of interval delays along the cancer care pathway and highlight care points that are acting as bottlenecks, thus delaying the management of patients with NSCLC. Overall, the median total wait time increased by 28 days immediately after regionalization, and then decreased by 8.5 days in the period 5 years after regionalization. However, there was an increase of 17.5 days in median total wait time between the first and the last cohorts. There were also differences in interval delays between the cohorts. For instance, wait times 5 years after regionalization seem to be primarily driven by an increase in staging completion time as well as delays in initial physician contact after the onset of symptoms. This increase was countered, to an extent, by shorter time for first consult with a surgeon after an abnormal CT scan and shorter time from staging completion to first treatment.

The total wait time, as well as the interval delays, for lung cancer management in our study were comparable to other published studies.[3,6,8,14–17] Two Canadian studies from tertiary hospitals in Hamilton, Ontario, and Montréal, Quebec, evaluated time delays in the care of patients with NSCLC.[8,17] The wait time from symptom onset to treatment in these studies was 138 days in Hamilton and 122 days in Montréal. Internationally, an American study evaluated the timelines of more than 48 000 Medicare patients with lung cancer and found that the median time from symptom onset to diagnosis was 187 days, which is 40 days longer than in our cohort with the longest wait time, immediately after regionalization.[6] However, each study used different time points for defining interval delays, rendering direct comparisons difficult.

In recent years, organized efforts have been made at the federal and provincial levels in Canada to evaluate wait times for cancer surgeries and improve access to timely care. Targets and benchmarks for wait times have been developed to keep track of progress and identify gaps in care. However, the time from referral to surgery and from surgery booking or decision to surgery, as reported by Health Quality Ontario and the Canadian Institute for Health Information, could not be compared with our study given the difference in intervals captured.[18,19] Although this provincial- and national-level reporting of wait times is crucial in tracking progress and highlighting opportunities for improvement, they capture only surgical wait times and do not capture all the delays that patients encounter throughout their cancer care journey, from diagnosis to management. Therefore, a comprehensive evaluation of total wait time and interval delays, and inclusion of all management modalities, can provide opportunities for identifying bottlenecks in care and can subsequently improve wait times, prognosis and quality of life for patients.

The effects of the implementation of clinical practice guidelines, diagnostic pathways and evidence-informed practice can be observed in our study. According to the guidelines of Cancer Care Ontario, patients with an abnormal chest radiograph or a high suspicion of lung

cancer based on clinical judgment should undergo a chest CT within 2 weeks.[5] The wait time for first CT scan was within this limit for all 3 cohorts. Additionally, compared with C2, the wait time for this segment was significantly shorter in C3 when regionalization was more settled. A more streamlined diagnostic process was adopted after regionalization through the implementation of clinical decision-making models (diagnostic pathways) developed by Cancer Care Ontario for primary care providers. These pathways provide a clinical schematic for providers that delineates the appropriate next steps based on a patient's initial presentation (i.e., Thoracic Diagnostic Assessment Programs).[20,21] Factors such as presenting symptoms, features suspicious of malignancy, comorbidities and risk factors, are taken into consideration and guide specialist referral and additional investigations for work-up. Based on the decision-making model for lung cancer, patients with a clinical picture suggestive of malignancy should swiftly undergo CT scanning for evaluation, which may prompt referral to the regional cancer centre for specialist consultation. These guidelines were likely more ingrained and in better circulation several years after regionalization compared with immediately after regionalization, which could explain the significant decrease in time to CT scans observed in C3. Furthermore, the absence of such decision-making models before regionalization likely led to increased referrals to respirologists, multiple presentations to the general practitioner before a CT scan or repeated imaging, evident in the significantly longer time to see a surgeon following an abnormal CT scan in C1 and C2 compared with C3. Further research should evaluate the effectiveness of these decision-making tools in modifying referral pathways (i.e., direct referral to the thoracic surgeon by the general practitioner or emergency physicians following an abnormal CT scan, or delayed referral after additional testing or referral to a respirologist), as they affect the overall wait time for the delivery of lung cancer care.

Our study showed an increase in time to completion of staging after regionalization which may be attributed to the inclusion of PET scans in the staging work-up. Comprehensive staging protocols for lung cancers after regionalization recommend an additional workup with a PET scan, magnetic resonance imaging of the brain and CT of the chest for all patients with NSCLC, in compliance with best practice guidelines and evidence from randomized control trials.[22–25] The observed increase of 5.5 days in the median wait time for PET scans between C2 to C3 suggests prolongaton of staging completion time. These findings are consistent with a large-scale retrospective study of time delays in the treatment of patients with NSCLC in the American Medicare system, which showed that the use of PET scans was associated with significantly lower rates of adherence to time delay targets.[26] In Ontario, PET scans became available as an insured service for patients with suspected NSCLC in 2009.[18] However, the number of PET scans allowed by the ministry was disproportionally lower than those required for comprehensive staging of the NSCLC population. Although this issue was resolved over time, and was therefore not a concern for C3, the interval delay for completion of staging after first surgeon visit remained significantly high in this cohort. These delays could be reduced by using nurse navigators to manage appointments for staging and functional tests. In addition, these delays also signify the important decision of delaying treatment in favour of appropriate staging, which could have important long-term benefits for prognosis.

Another unexplained finding in our study is the significantly higher wait time from symptom onset to initial visit with the physician 5 years after regionalization compared to the earlier study periods. In the absence of this delay, the total wait time would have been 111 days for C3, 11 days shorter than C1. There are a few possible explanations. First, there could have been an overall increase in wait time to see a general practitioner in the region. Second, a significantly lower proportion of patients in this cohort (24%) first presented in the emergency department compared to the other cohorts (44% in C1, 34% in C2) which could have increased wait time from symptom onset to initial physician visit for these patients. However, after adjusting for the type of first physician in the adjusted model, the wait time from symptom onset to initial visit was still significantly higher for C3. Third, the time for symptom onset is based on patient recall, which could result in differences between cohorts; however, we do not have a reason to assume the patients in C3 would recall differently than other cohorts. Therefore, further research is needed to evaluate if regionalization inadvertently created a bottleneck to get a consult appointment with the thoracic surgeon.

Overall, breaking down the care pathway allowed for a more granular understanding of bottlenecks in care and the effects that restructuring care had on wait times. Furthermore, we included the cohort immediately after regionalization to highlight the challenges in care delivery in this period. Some of the challenges include additional delays because of the implementation of guidelines in the care pathway that did not have adequate infrastructure or availability (e.g., CT and PET scans). We believe this information could be of interest to other jurisdictions, as well as the global readers, that may consider regionalization of cancer care. Regionalization is much more than a shift in patient care to high volume centres. In actuality, it inevitably requires increased resource use, which in turn requires planning to ensure the provision of efficient, high-quality, seamless care.

Limitations

As with any retrospective chart review, we were unable to obtain real-time data on all patients, thus relying on patient recall and physicians' recording of data to determine the care pathway. Endobronchial ultrasound replaced cervical mediastinoscopy in select instances in high-volume hospitals, which may have resulted in some sampling bias by precluding patients with advanced disease. There are no standard definitions for interval delays in the management of NSCLC, which limited comparison with the literature. The 2 hospitals in our study served different geographic areas. Unmeasured demographic differences, patient attitudes, adherence and choice of treatment may have influenced time delays. Some of the differences observed between cohorts (e.g., time delays, referral patterns, staging modalities, use of PET scan) may also be explained by the inherent differences between low- and high-volume hospitals, as opposed to being entirely the effect of regionalization. It was difficult to untangle what differences were because of disparities in clinical volume versus regionalization. In addition, there are practical challenges with finding a single centre that was low volume before regionalization and that became a high-volume centre after regionalization. There are many moving parts in the care continuum, and even after adjusting for patient-, provider- and disease-specific factors, we could not control for the effect of resource availability. As this study represents the experience of a single surgeon, the generalizability of results to other institutions may be limited.

Conclusion

Our study showed the effects of the regionalization of care and the implementation of clinical practice guidelines on wait times for NSCLC in the practice of a single surgeon. Although trends toward reduction in wait times between different care points are evident, we did not identify any statistically significant changes in total wait time to receive treatment for NSCLC after regionalization. Our study, however, highlights specific wait time segments in the period after regionalization in which a meaningful reduction in wait times is possible with the implementation of appropriate processes of care, such as easier access to primary care, availability of resources before implementation of clinical practice guidelines and using dedicated patient care navigators throughout the cancer care pathway. Future studies should address whether or not further reductions in staging completion time translates into improved outcomes in oncological care.

Acknowledgements: The authors thank Dr. Jason W. Lee for his contribution in data collection.

Affiliations: From the School of Medicine, University of Toronto, Toronto, Ont. (Shakeel, Dhanoa, Khan, Dibajnia, Behzadi); the Department of Oncology, Trillium Health Partners, Mississauga, Ont. (Dibajnia, Behzadi); the Department of Medicine, Health Sciences North, Sudbury, Ont. (Dibajnia); the Northern Ontario School of Medicine, Laurentian University, Sudbury, Ont. (Dibajnia); the School of Nursing, McMaster University, Hamilton, Ont. (Akhtar-Danesh); and the Department of Surgery, University of Toronto, Toronto, Ont. (Behzadi).

Competing interests: None declared.

Contributors: Saad Shakeel, Pooya Dibajnia and Abdollah Behzadi contributed to the conception and design of the work. Saad Shakeel, Mankeeran Dhanoa, Omar Khan and Noori Akhtar-Danesh acquired, analyzed and interpreted the data. Saad Shakeel, Mankeeran Dhanoa, Omar Khan and Abdollah Behzadi drafted the manuscript. All authors revised the manuscript 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.

References

1. Canadian Cancer Society. *Canadian cancer statistics 2017*. Toronto: Canadian Cancer Society; 2017.
2. Berwick DM. A user's manual for the IOM's "quality chasm" report. *Health Aff*. 2002;21:80-90.
3. Kasymjanova G, Small D, Cohen V, et al. Lung cancer care trajectory at a Canadian centre: an evaluation of how wait times affect clinical outcomes. *Curr Oncol* 2017;24:302-9.
4. Lennes IT, Lynch TJ. Quality indicators in cancer care: development and implementation for improved health outcomes in non-small-cell lung cancer. *Clin Lung Cancer* 2009;10:341-6.
5. Del Giudice ME, Young S-M, Vella ET, et al. Guideline for referral of patients with suspected lung cancer by family physicians and other primary care providers. *Can Fam Physician* 2014;60:711-6, e376-82.
6. Nadpara P, Madhavan SS, Tworek C. Guideline-concordant timely lung cancer care and prognosis among elderly patients in the United States: A population-based study. *Cancer Epidemiol* 2015;39:1136-44.
7. Diaconescu R, Lafond C, Whittom R. Treatment delays in non-small cell lung cancer and their prognostic implications. *J Thorac Oncol* 2011;6:1254-9.
8. Salomaa ER, Sällinen S, Hiekkanen H, et al. Delays in the diagnosis and treatment of lung cancer. *Chest* 2005;128:2282-8.
9. Redaniel MT, Martin RM, Ridd MJ, et al. Diagnostic intervals and its association with breast, prostate, lung and colorectal cancer survival in England: historical cohort study using the Clinical Practice Research Datalink. *PLoS One* 2015;10:e0126608.
10. Bendzsak AM, Baxter NN, Darling GE, et al. Regionalization and outcomes of lung cancer surgery in Ontario, Canada. *J Clin Oncol* 2017;35:2772-80.
11. Sundaresan S, McLeod R, Irish J, et al. Early results after regionalization of thoracic surgical practice in a single-payer system. *Ann Thorac Surg* 2013;95:472-8.
12. Finley C, Schneider L, Shakeel S. Approaches to high-risk, resource intensive cancer surgical care in Canada. 2015. Available: www.cancerview.ca/idc/groups/public/documents/document/high_risk_resource_full_report_en.pdf (accessed 2019 Oct. 26).

13. Simunovic M, Rempel E, Thériault ME, et al. Influence of hospital characteristics on operative death and survival of patients after major cancer surgery in Ontario. *Can J Surg* 2006;49:251-8.
14. Labbé C, Anderson M, Simard S, et al. Wait times for diagnosis and treatment of lung cancer: a single-centre experience. *Curr Oncol* 2017;24:367–73.
15. Rastpour A, Begen MA, Louie AV, et al. Variability of waiting times for the 4 most prevalent cancer types in Ontario: a retrospective population-based analysis. CMAJ Open 2018;6:E227–34.
16. Ellis PM, Vandermeer R. Delays in the diagnosis of lung cancer. *J Thorac Dis* 2011;3:183-8.
17. Liberman M, Liberman D, Sampalis JS, et al. Delays to surgery in non–small-cell lung cancer. *Can J Surg* 2006;49:31–6.
18. Canadian Institute for Health Information. *Wait times*. Ottawa: Canadian Institute for Health Information; Available: https://www.waittimes.cihi.ca (accessed 2019 Oct. 19).
19. Health Quality Ontario. *System performance*. Toronto: Health Quality Ontario. Available: https://www.hqontario.ca/System-Performance/Wait-Times-for-Surgeries-and-Procedures/Wait-Times-for-Cancer-Surgeries/Time-to-Patients-First-Cancer-Surgical-Appointment (accessed 2019 Oct. 19).
20. Cancer Care Ontario. *Lung cancer diagnostic pathway map*. Toronto: Cancer Care Ontario. Available: https://www.cancercareontario.ca/sites/ccocancercare/files/assets/LungDiagnosisPathwayMap.pdf (accessed 2019 Oct. 26).
21. Cancer Care Ontario. *Referral of suspected lung cancer by primary care practitioners*. Toronto: Cancer Care Ontario. Available: https://www.cancercareontario.ca/en/content/referral-suspected-lung-cancer-primary-care-practitioners (accessed 2019 Oct. 19).
22. Silvestri GA, Gonzalez AV, Jantz MA, et al. Methods for staging non-small cell lung cancer: diagnosis and management of lung cancer, 3rd ed: American college of chest physicians evidence-based clinical practice guidelines. *Chest* 2013;143: e211S-50S.
23. Ung YC, Maziak DE, Vanderveen JA, et al. ^{18}Fluorodeoxyglucose positron emission tomography in the diagnosis and staging of lung cancer: a systematic review. *J Natl Cancer Inst* 2007;99:1753-67.
24. Fischer B, Lassen U, Mortensen J, et al. Preoperative staging of lung cancer with combined PET–CT. *N Engl J Med* 2009;361:32-9.
25. Van Tinteren H, Hoekstra OS, Smit EF, et al. Effectiveness of positron emission tomography in the preoperative assessment of patients with suspected non-small-cell lung cancer: the PLUS multicentre randomised trial. *Lancet* 2002;359:1388-93.
26. Gomez DR, Liao KP, Swisher SG, et al. Time to treatment as a quality metric in lung cancer: Staging studies, time to treatment, and patient survival. *Radiother Oncol* 2015;115:257-63.