Original Study

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Thoracic Oncology Multidisciplinary Clinic Reduces Unnecessary Health Care Expenditure Used in the Workup of Patients With Non–small-cell Lung Cancer

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Abstract

For patients with non–small-cell lung cancer requiring definitive multimodality care (radiation, chemotherapy, surgery), evaluation through a coordinated single-day multidisciplinary clinic reduced $5839 in hospital charges per patient during the 90-day diagnostic period prior to treatment when compared with evaluation through traditional sequential referral-based thoracic oncology clinics. This corresponded to a 23% charge reduction per patient.

Background: National costs of lung cancer care exceed $12 billion. We investigate the resource-savings benefit of a single-day thoracic oncology multidisciplinary clinic (MDC) in the diagnostic period prior to non–small-cell lung cancer (NSCLC) treatment. **Materials and Methods:** From July 2007 to January 2015, patients with NSCLC treated with multimodality therapy at a tertiary hospital-based cancer center in Maryland were identified. Patient and treatment details were collected. Health care resources utilized in the 90 days prior to receipt of first oncologic treatment were identified using billed activity codes. Associated total charges, including professional fees and hospital-based technical fees, were identified and inflated to 2014 dollars using the Consumer Price Index. Codes were categorized into provider visits, procedures, pathology/laboratory, radiology, and other tests. χ^2, Student *t*, and Wilcoxon rank-sum tests compared charges of patients seen in and out of the MDC. **Results:** Two-hundred ninety-seven (non-MDC = 161, 54%; MDC = 136, 46%) of 308 patients identified had total charges available. Patients seen through MDC had on average a 23% decrease in total charges per patient incurred ($5839 savings; range, $5213-$6464) compared with patients seen through non-MDC settings. Evaluation through MDC reduced the average number of provider visits per patient (non-MDC, 6.8 vs. MDC, 4.8; $P < .01$) prior to treatment start, which led to a 50% (average $3092; range, $2451-$3732) reduction in provider charges per patient ($P < .01$). **Conclusions:** Evaluation of patients with NSCLC through a coordinated single-day MDC reduced hospital charges per patient by 23% during the diagnostic period prior to treatment when compared with evaluation through traditional referral-based thoracic oncology clinics.

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Introduction

Cancer care costs in the United States represent a large strain to individuals, medical providers, health care institutions, and to society. The cost of cancer care is projected to reach $158 billion by 2020.[1] National costs of lung cancer care exceed $12 billion.[2] Leading national and international organizations, such as the American Society of Clinical Oncology, have developed and continue to revise a "value framework" that emphasizes the relationship between clinical benefit, toxicity, and cost in order to address this value challenge.[1,3] In health care, value is defined as providing improved clinical outcomes at lower costs.[4]

Patients with lung cancer requiring multimodality care are subject to complex evaluation and management algorithms necessitating input from thoracic surgeons, medical oncologists, radiation oncologists, interventional pulmonologists, radiologists, and pathologists.[5] Cancer care is traditionally delivered through department-based health care delivery models, where a patient with a new diagnosis of cancer will visit with one specialist from one department before being referred to the next specialist from another department for additional therapeutic recommendations. In contrast, in disease-based health care models, visits with specialists are coordinated in time and space and often coordinated in multidisciplinary clinics (MDCs) to provide better integrated patient-centered care.

At our institution, coordinated single-day MDCs have been implemented for patients with a new diagnosis of cancer over the past decade with demonstrated benefit in improving cancer care endpoints including accuracy of diagnosis, accuracy of treatment, time to treatment, treatment along national clinical practice guidelines, and research enrollment among patients with cancer.[6-9] Specifically, in 2 retrospective analyses of 308 and 220 patients with non—small-cell lung cancer (NSCLC), the improved coordination of care for patients seen in the MDC translated into a 3- to 9-month survival benefit when compared with patients evaluated and managed out of the MDC.[10,11]

Although these observations support the clinical benefits of a single-day MDC, data is lacking to support the economic benefit of cancer care provided in such coordinated health care models. In a systematic review of 14 studies evaluating multimodality cancer and non-cancer care provided in traditional department-based health care models, there was no demonstrated economic value added by tumor board discussions where patients were only discussed among providers, but not evaluated by all critical providers in clinic.[12] Further studies are needed to explore the potential resource utilization differences of lung cancer care delivered in coordinated disease-based as compared traditional department-based health care models.

Herein, we report a patient-level charge comparison of healthcare resources used in the 90-day workup period prior to treatment for patients with NSCLC, who required multimodality therapy including definitive radiotherapy, seen within a single-day MDC and seen out of the MDC. We assessed the potential initial economic benefit to managing these patients with NSCLC within a coordinated single-day clinic.

Patients and Methods

Patient Selection

Patients with stage II to III NSCLC treated with multimodality therapy at a Maryland-based tertiary academic center from July 2007 to January 2015 were analyzed using an institutional review board-approved database (IRB00164116). Patients were either initially seen within the institution's single-day MDC or within traditional referral-based thoracic oncology clinics (non-MDC) within the same institution. Prior to inception of the institution's single-day thoracic oncology MDC in October 2011, all patients were seen within traditional referral-based clinics. After the inception of the MDC, patients were referred to the MDC if they required new input or management from at least 2 thoracic specialties. Those referred included patients with a new diagnosis of NSCLC by interventional pulmonology, patients referred to medical oncology without evidence of distant metastases, or patients with stage II to III NSCLC deemed appropriate for MDC evaluation by thoracic surgery, medical oncology, or radiation oncology. Study inclusion criteria included: (1) stage II to III NSCLC at initial diagnosis or at recurrence, (2) receipt of 2 or more therapies (conventionally fractionated radiotherapy, chemotherapy, surgery), and (3) availability of all institutional patient service charges. We only included patients with NSCLC with an upfront need for multimodality therapy, given the need for timely coordination of care among specialists to expedite the start of potentially curative therapy.

Prior to evaluation in the MDC, an advanced nurse practitioner with expertise in lung cancer reviews available patient records, arranges for the MDC visit, and, when possible, arranges for completion of staging studies prior to or on the day of the MDC visit. Within the single-day MDC, patients arrive for a full-day where they first receive patient education and evaluation by a MDC provider in the morning. Thoracic surgeons, medical oncologists, radiation oncologists, radiologist, pathologists, social workers, and pharmacists then co-localize in one room to review, in a tumor-board fashion, each patient's history and physical performance status, diagnostic tests, diagnostic images, and pathology to formulate a consensus multidisciplinary tumor stage and treatment plan. Recommendations are then communicated to the patient by each involved lung cancer specialist in the afternoon (see Supplemental Figure 1 in the online version). In comparison, non-MDC patients with NSCLC are seen by an initial thoracic oncology provider, then referred to and seen by subsequent thoracic specialists in a sequential fashion. After the inception of the MDC, patients with NSCLC requiring multimodality care were still seen in traditional referral-based clinics if they were already evaluated by one of the treating specialties, but did not need additional input from 2 or more other treating specialties.

Baseline patient and treatment characteristics were obtained from retrospective chart review. Characteristics included age, gender, race, marital status, employment status, smoking status, recorded Eastern Cooperative Oncology Group performance status, American Joint Committee on Cancer (AJCC) seventh edition overall group stage,[5] tumor stage, nodal stage, tumor histology, and time from first

Table 1 Comparison of Clinical Characteristics Between 297 Patients With Non–small-cell Lung Cancer, Non-MDC Versus MDC

	Non-MDC		MDC		
	161 (54)		136 (46)		
Characteristics	**#**	**%**	**#**	**%**	***P* Value**
Median age, y (IQR)	65	57-72	66	58.5-72.5	.36
Gender					.60
Male	91	56.5	81	59.6	
Female	70	43.5	55	40.4	
Race					.79
White	97	60.3	84	61.8	
Black/other	64	39.8	52	38.2	
Married	95	59.0	78	57.4	.77
Employed	51	31.7	49	36.0	.72
Residence					.11
In state	138	85.7	107	78.7	
Out of state	23	14.3	29	21.3	
Smoking status					.54
Never	11	6.8	14	10.3	
Former	80	49.7	63	46.3	
Current	70	43.5	59	43.4	
ECOG performance status					< .001
0 or 1	79	49.1	107	78.7	
2	8	5.0	14	10.3	
Unknown	74	46.0	15	11.0	
AJCC 7 group stage					.29
II	17	10.6	8	5.9	
IIIA	95	59.0	80	58.8	
IIIB	49	30.4	48	35.3	
Tumor stage					.002
0	3	1.9	5	3.7	
1	34	21.1	28	20.6	
2	52	32.3	38	27.9	
3	42	26.1	16	11.8	
4	30	18.6	49	36.0	
Nodal stage					.23
0	12	7.5	19	14.0	
1	18	11.2	13	9.6	
2	104	64.6	77	56.6	
3	27	16.8	27	19.9	
Histology					.02
Adenocarcinoma	74	46.0	81	59.6	
Squamous cell	61	37.9	45	33.1	
Other[a]	26	16.2	10	7.4	
Median time from first oncologic visit to treatment, d (IQR)	34	21-50	24	19-34.5	< .001

Abbreviations: AJCC 7 = American Joint Committee on Cancer 7th Edition; ECOG = Eastern Cooperative Oncology Group; IQR = interquartile range; MDC = patients saw specialists within the single-day thoracic oncology multidisciplinary clinic; Non-MDC = patients saw specialists sequentially out of the single-day thoracic oncology multidisciplinary clinic.
[a]Includes carcinoma not-otherwise-specified.

Table 2 Comparison of Total Charges Utilized in the Workup of Lung Cancer, Non-MDC Versus MDC (n = 297)

	Non-MDC		MDC		
	n = 161 (54%)		n = 136 (46%)		
	Average	95% CI	Average	95% CI	*P* Value
Provider visits	$6182	$4827-$7537	$3090	$2376- $3805	< .001
Procedure	$7061	$6180-$7943	$6000	$5227-$6772	.07
Pathology/lab	$3260	$2823-$3698	$3165	$2757-$3573	.06
Radiology					
CT	$1166	$981-$1351	$919	$751-$1087	.052
MRI	$914	$713-$1115	$1012	$764-$1260	.54
PET/CT	$3326	$2877-$3776	$3405	$2896-$3913	.82
Radiology-other	$967	$744-$1190	$547	$384-$709	.003
Other	$2955	$2026- $3885	$1857	$678-$3036	.14
Total	$25,833	$22,528-$29,137	$19,994	$17,315-$22,673	< .001

Abbreviations: CT = computed tomography; Lab = laboratory; MDC = patients saw specialists within the single-day thoracic oncology multidisciplinary clinic; MRI = magnetic resonance imaging; Non-MDC = patients saw specialists sequentially out of the single-day thoracic oncology multidisciplinary clinic; PET = positron emission tomography.

oncology-related visit to first cancer treatment. Date of first oncology-related visit was defined as date of biopsy or first visit with interventional pulmonary, thoracic surgery, medical oncology, or radiation oncology, whichever came first. Date of first cancer treatment was defined as the date of start of lung cancer therapy including chemotherapy, radiation therapy, or thoracic surgery, whichever came first.

Lag Analysis of Resources Utilized in the Workup of NSCLC

All patients were evaluated in a hospital-based ambulatory clinic environment. As such, a comprehensive overview of the patient services provided was obtained by reviewing hospital-based and professional-based billing codes and their associated charges, both outpatient and inpatient.

Billing codes associated with the patient encounters that occurred in the 90 days prior to first cancer treatment were obtained. Billing codes were categorized into provider visits, procedures, pathology/laboratory tests, radiology studies, and other to reflect the standard diagnostic studies used in the work-up of newly diagnosed NSCLC.[5] Billing codes associated with radiology encounters were further sub-categorized into computed tomography (CT) scans, magnetic resonance imaging (MRI) scans, position-emission tomography/CT (PET/CT) scans, and other radiologic tests. Procedures included bronchoscopy, mediastinoscopy, thorascopy, percutaneous biopsy, thoracentesis, and pulmonary function tests.

Associated Charges in the Workup of NSCLC

The health system's financial analysis unit extracted the patient service charges associated with available billing codes. Common

Table 3 Comparison of Resources Utilized by CPT Counts per Patient in the Workup of Lung Cancer, Non-MDC Versus MDC (n = 297)

	Non-MDC		MDC		
	161 (54%)		136 (46%)		
	Average	95% CI	Average	95% CI	*P* Value
Provider visits	6.8	5.9-7.7	4.8	4.2-5.5	< .001
Diagnostic - procedural	6.8	6.2-7.5	7	6.5-7.7	.59
Pathology/lab	6.7	5.8-7.7	6.9	5.7-8.1	.83
Radiology					
CT	3	2.6- 3.3	3.1	2.7-3.6	.57
MRI	1.4	1.2-1.6	1.3	1.2-1.5	.61
PET/CT	1.2	1.1-1.4	1.4	1.2-1.6	.2
Radiology-other	3.7	3.1-4.2	3.7	2.8-4.6	.99
Other	3.8	3.1-4.5	2.9	2.2-3.5	.06
Total	28.3	25.6-31.0	26.0	23.6-28.3	.19

Abbreviations: CPT = Current Procedural Terminology; CT = computed tomography; Lab = laboratory; MDC = patients saw specialists within the single-day thoracic oncology multidisciplinary clinic; MRI = magnetic resonance imaging; Non-MDC = patients saw specialists sequentially out of the single-day thoracic oncology multidisciplinary clinic; PET = positron emission tomography

Procedural Terminology codes were used to identify professional fees charges for physician services. Hospital-specific billing codes were used to identify technical fee charges for hospital services, which included charges for facility, equipment, and supply use. Charges were combined and inflated to 2014 equivalent United States dollars using the Consumer Price Index for Medical Care provided by the Bureau of Labor and Statistics.[13]

Statistical Analyses

Descriptive statistics were used to describe baseline patient and treatment characteristics. The Student *t* test, χ^2 test, and Wilcoxon rank-sum test were used to compare the MDC and non-MDC cohorts. Graphical plots were used to display average values for charges and counts of resources used in the work-up of these patients with NSCLC.

Results

Patient Details

Of the 308 patients with stage II to III NSCLC who required multimodality care involving 2 or more providers, total charges were available for 297 patients and were included in this analysis.

In the total cohort of 297 patients, the median age was 65 years (interquartile range [IQR], 58-72 years), 58% (n = 172) were men, 61% (n = 181) were white, and 82% (n = 249) were in-state patients. The non-MDC and MDC cohorts had similar distribution of clinical characteristics, except for distribution of recorded Eastern Cooperative Oncology Group performance status, AJCC tumor (T) stage, tumor histology, and median number of days from initial oncologic encounter to receipt of first cancer treatment ($P < .05$) (Table 1). Patients seen within the MDC were more likely to have documentation of baseline performance status (MDC, 11% unknown vs. non-MDC, 46% unknown). This was congruent with a standardization of clinical documentation that included performance status for patients seen in MDC. Patients with lung cancer had the similar distribution of overall AJCC group stage; however, patients in the MDC cohort had a higher T4 tumor stage (MDC, 36% vs. non-MDC, 19%) and had an increase in tumors categorized as adenocarcinoma (MDC, 60% vs. non-MDC, 46%). This increase in adenocarcinoma histologic classification was concordant with a decrease in patients classified as "other" lung cancers (MDC, 7% vs. non-MDC, 16%), which included carcinoma not otherwise specified. Patients in the MDC cohort also had a decrease in the median number of days from their first visit with a provider regarding their lung cancer to the receipt of their first lung cancer treatment (MDC, 24 days vs. non-MDC, 34 days; $P \leq .001$).

Total Charges Associated with the Workup of NSCLC

Total charges, a sum of professional fee and hospital-based charges, were compared between patients in the MDC and non-MDC groups. On average, patients with NSCLC seen in the single-day MDC had a 23% decrease in total charges per patient incurred in the 90 days prior to start of their lung cancer treatment (a $5839 savings; 95% confidence interval [CI], $5213-$6464) compared with patients seen in traditional sequential referral-based clinics in the same institution (Table 2) (see Supplemental Figure 2 in the online version).

The majority of the savings arose from a reduction in total charges associated with provider visits (Table 2). Patients with NSCLC seen within the single-day MDC had a 50% ($3092) average reduction in total provider visit charges per patient (MDC, average $3090; 95% CI, $2376-$3805 vs. non-MDC, average $6182; 95% CI, $4827-$7537; $P < .001$). There was also a 43% ($420) average reduction in total charges per patient associated with other radiologic exams that were non-CT, non-MRI, or non-PET/CT scans (MDC, $547; 95% CI, $384-$709 vs. non-MDC, $967; 95% CI, $744-$1190; $P = .003$).

There was also a trend toward a reduction in averages charges per patient with NSCLC seen within the single-day MDC as compared with out of the MDC for the following studies: procedures (average 15% [$1061] savings; $P = .07$), CT scans (average 21% [$247] savings; $P = .052$), and pathology/laboratory tests (average 3% [$95] savings; $P = .06$).

Health Care Resources Utilized in the Workup of NSCLC

The professional fee billing codes for the patient services utilized were evaluated for 297 patients as a proxy of the number of unique health care resources used in the workup of NSCLC.

On average, patients with NSCLC seen within the single-day MDC had less provider visits prior to initiating their lung cancer care (4.8; 95% CI, 4.2-5.5) compared with non-MDC patients (6.8; 95% CI, 5.9-7.7; $P < .001$) (Table 3) (see Supplemental Figure 3 in the online version). There was a trend towards decreased "other" exams performed on patients in the MDC cohort compared with those in the non-MDC group (MDC, 2.9; 95% CI, 2.2-3.5 vs. non-MDC, 3.8; 95% CI, 3.1-4.5; $P = .06$). These other exams were separate from the standard laboratory, procedural, and imaging-based exams used in the workup of NSCLC. These other exams included additional biopsies, other diagnostic tests such as echocardiograms, other cancer screening exams, and procedures used in the management of other concurrent medical comorbidities. Supplemental Tables 1 and 2 (in the online version) list studies categorized as "Radiology-other" and "Other," respectively.

Discussion

In this large series of patients with stage II to III NSCLC requiring multimodality therapy, we identify that patients who received initial lung cancer care coordinated through a single-day thoracic oncology MDC had a 23% ($5839) reduction on average in total charges per patient incurred in the diagnostic workup period prior to the start of cancer treatment when compared to patients in the non-MDC group treated at the same institution.

In the context of the value framework of improving lung cancer care while reducing cost, our single-day MDC was able to add value in the NSCLC diagnostic period by expediting time to initiation of lung cancer treatment and increasing documentation of baseline performance status, as well as reducing charges associated with lung cancer workup. This reduction in charges would correspond to an average reduction of $794,000 incurred among all 136 patients seen in the single-day MDC at our institution. If this coordinated disease-based model is applied to all of the

234,000 new cases of lung cancer diagnosed a year in the United States[14] — there is potential for a significant reduction in health care resources utilized and improvement of the value of health care delivered in the diagnostic workup period of patients with NSCLC.

There are limited analyses demonstrating the economic value of MDCs in cancers.[12,15] In a retrospective cost analysis of patients with stage I to II melanoma, evaluation and treatment of patients with melanoma through a MDC resulted in a reduction of $1600 per patient during the diagnosis and initial management period when compared with referral-based clinics.[16] MDCs decreased the average number of office visits, radiology tests, blood tests, pathology reports, and anesthetic services performed.[16] Our study showed a similar incremental reduction in charges in patients with NSCLC. However, this charge analysis was limited to the workup period of patients with NSCLC, who face greater complexity in the evaluation and management of their cancer, given the need for coordinated multimodality treatment.

Several points deserve consideration. Our analysis was retrospective, limited to the billed charges incurred in a multi-hospital health care institution, and analyzed data from a multi-year time period. As such, our analysis cannot account for the impact of year in which the patient was evaluated or for potential selection biases, as more patients seen in MDC were staged in consensus by treating specialists as having T4 tumors. This analysis also assumed that the majority of the NSCLC workup would have been captured using billing data from the 90-day period prior to receipt of oncologic treatment. In addition, resources used to coordinate a single-day MDC such as the time used by an advanced nurse practitioner to triage patients and their workup and potential changes in the productivity of involved specialists are not captured in this charge analysis. Lastly, this analysis presented charge data as a proxy of costs. Charges reflect the amount that a hospital bills its patients for services provided; it may not reflect the true costs of services nor the payment received for services provided.[4] Typically, health care charges are overinflated and may be adjusted with cost-to-charge conversion scales to better reflect true costs. As the majority of the care provided in this analysis was outpatient hospital-based oncology care, the Centers of Medicare and Medicaid Services inpatient cost-to-charge adjustment ratio was not applied in this analysis.[17]

Despite these limitations of our analysis, our study demonstrates the value of a single-day thoracic oncology MDC in reducing resources charged in the work-up of NSCLC within one institution. To further build on this study, future research should include determining the potential value of a single day-coordinated thoracic oncology MDC throughout the entirety of the lung cancer treatment continuum—from the health care, patient, and societal perspectives. In addition, further studies are needed to evaluate the ability of community-based practices to operationalize a single-day MDC model of multidisciplinary lung cancer care. These findings would support further coordination of lung cancer care through disease-based health care deliver models, such as single-day coordinated MDCs.

Clinical Practice Points

- Data are lacking to support the economic benefit of cancer care provided in coordinated disease-based health care models, such as MDCs, where visits with specialists are coordinated in time and space in to provide better integrated patient-centered care.
- Patients with lung cancer requiring multimodality care are subject to complex evaluation and management algorithms necessitating input from thoracic surgeons, oncologists, radiation oncologists, interventional pulmonologists, radiologists, and pathologists.
- Our study showed that, in patients with stage II to III NSCLC who required multimodality therapy and received initial cancer treatment recommendations through a coordinated single-day thoracic oncology MDC, there was a 23% reduction in total charges on average per patient incurred in the diagnostic workup period prior to the start of lung cancer treatment when compared with patients in the non-MDC cohort treated at the same institution.
- The charge data from the present study support the initial economic value added by a coordinated a single-day MDC model of lung cancer care delivery.
- If this coordinated disease-based model is applied to the management of newly diagnosed lung cancer requiring multimodality therapy in the United States, there is potential for a modest, but significant reduction in unnecessary health care resources utilized in the diagnostic workup period.

Disclosure

The authors have stated that they have no conflicts of interest.

Supplemental Data

Supplemental tables and figures accompanying this article can be found in the online version at https://doi.org/10.1016/j.cllc.2019.02.010.

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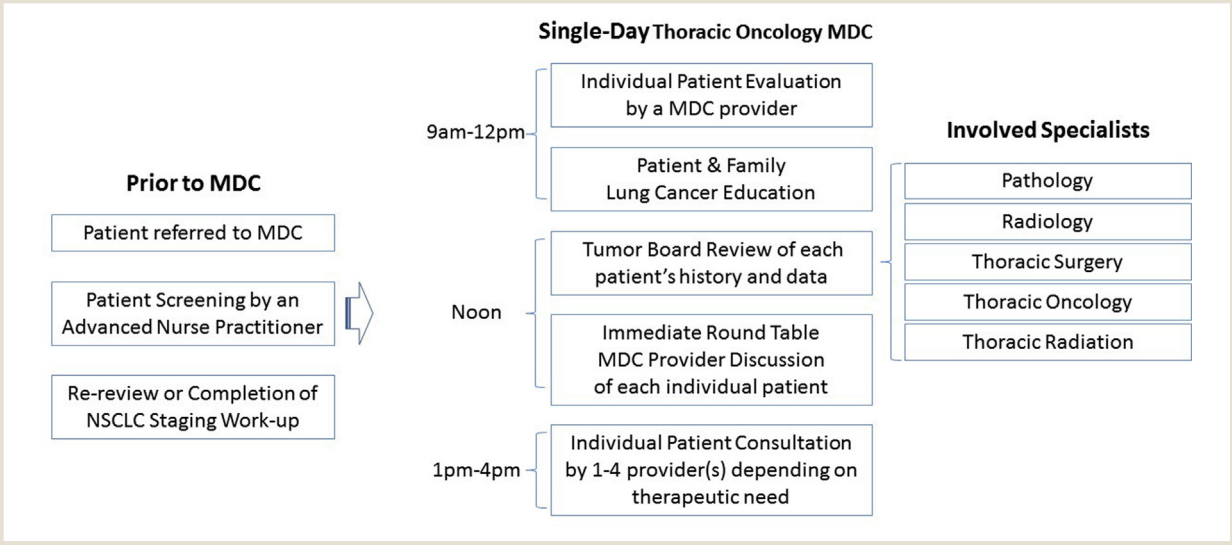
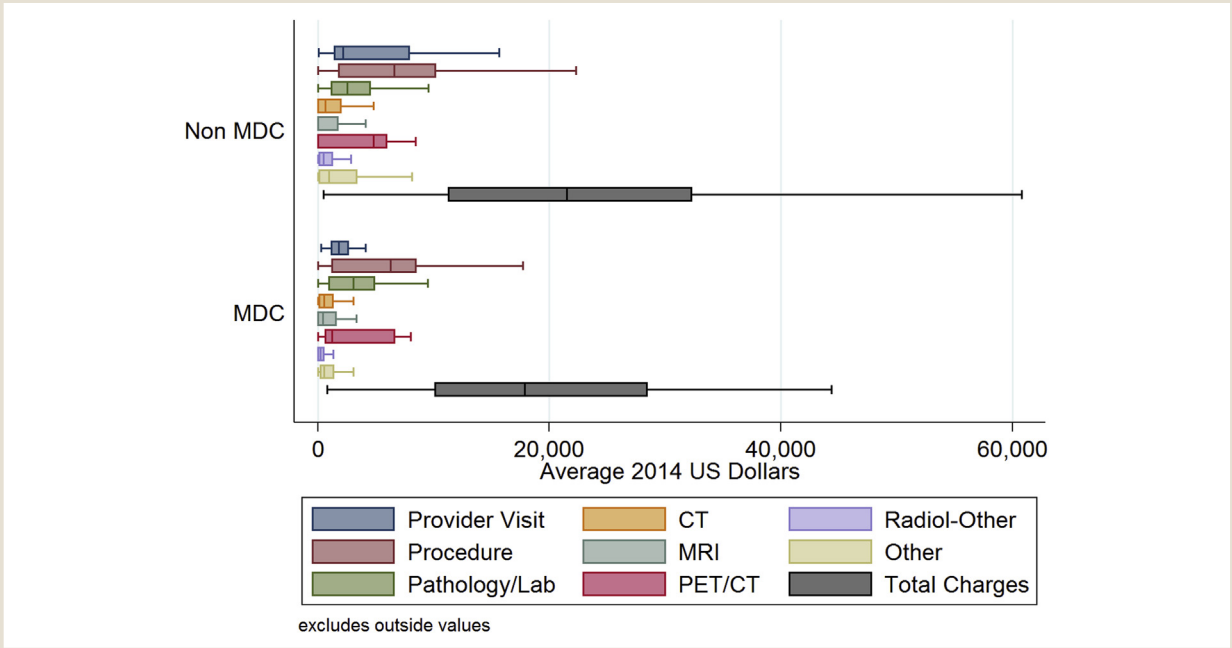
Supplemental Figure 1 Workflow of the Single-day MDC for Patients With NSCLC



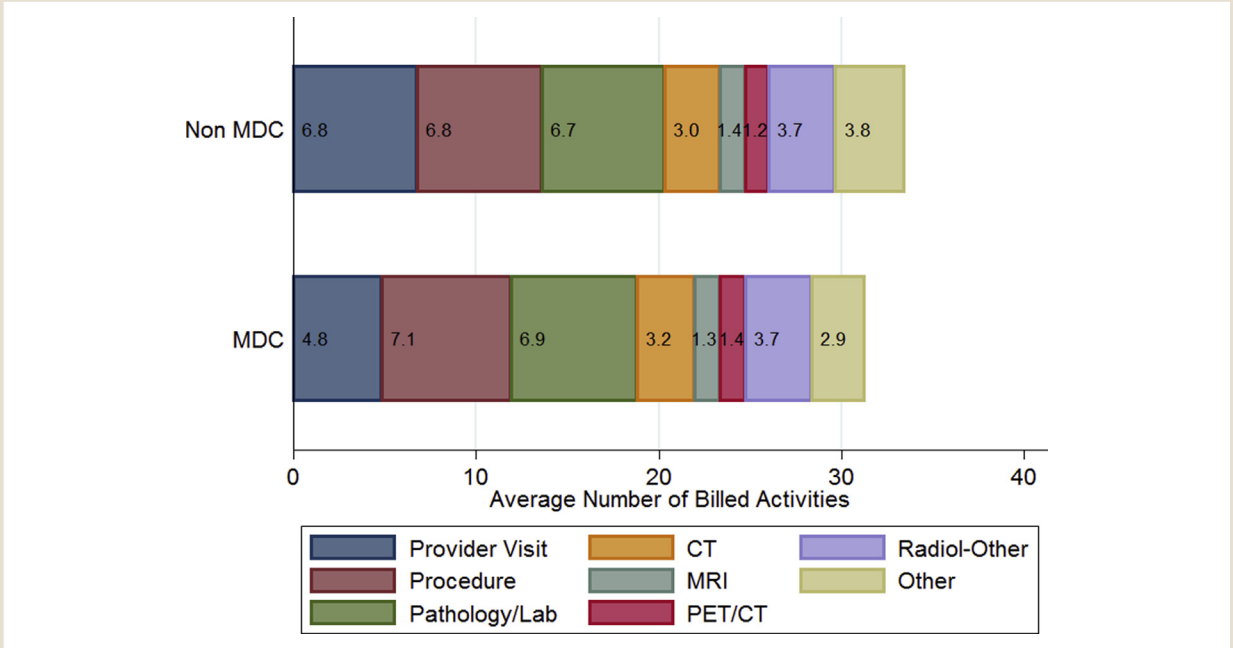
Abbreviations: MDC = thoracic oncology multidisciplinary clinic; NSCLC = non–small-cell lung cancer.

Supplemental Figure 2 Average Total Charges per Patient Associated With Health Care Resources Utilized in the Workup of NSCLC. Total Charges Consist of Both Professional Fee and Technical Fee Charges Available for Patient Encounters That Occurred in the 90 Days Prior to First Oncologic Treatment



Abbreviations: CT = computed tomography; Lab = laboratory tests; MDC = multidisciplinary clinic; MRI = magnetic resonance imaging; NSCLC = non–small-cell lung cancer; PET = positron emission tomography; Radiol-Other = other radiologic tests.

Supplemental Figure 3 **Average Number of Health Care Resources Utilized Per Patient in the Workup of NSCLC. The Number of Billed Health Care Activities for the 297 Patients With NSCLC With Were Determined Using Common Procedural Terminology Codes That Were Associated With Patient Encounters Occurring in the 90 Days Prior to First Oncologic Treatment. The Average Number of Billed Activities per Category of Billed Activity Are Displayed Within the Respective Bars of the Graph**



Abbreviations: CT = computed tomography; Lab = laboratory tests; MDC = multidisciplinary clinic; MRI = magnetic resonance imaging; NSCLC = non–small-cell lung cancer; PET = positron emission tomography; Radiol-Other = other radiologic tests.

Supplemental Table 1 Studies Included in "Radiology-Other" Category

Billing Code	Description
70030	RADIOLOGIC EXAMINATION EYE DETECT FOREIGN BODY
70548	MRA NECK W/CONTRAST MATERIAL
71020	RADIOLOGIC EXAM CHEST 2 VIEWS FRONTAL&LATERAL
71034	RADEX CHEST COMPLETE MINIMUM 4 VIEWS W/FLUORO
71035	RADEX CHEST SPECIAL VIEWS
71100	RADEX RIBS UNILATERAL 2 VIEWS
71101	RADEX RIBS UNI W/POSTEROANT CH MINIMUM 3 VIEWS
71130	RADEX STERNOCLAVICULAR JT/JTS MINIMUM 3 VIEWS
72040	RADEX SPINE CERVICAL 3 VIEWS OR LESS
72050	RADEX SPINE CERVICAL 4 OR 5 VIEWS
73010	RADEX SCAPULA COMPLETE
73030	RADEX SHOULDER COMPLETE MINIMUM 2 VIEWS
73060	RADEX HUMERUS MINIMUM 2 VIEWS
73090	RADEX FOREARM 2 VIEWS
73110	RADEX WRIST COMPLETE MINIMUM 3 VIEWS
73130	RADEX HAND MINIMUM 3 VIEWS
73220	MRI UPPER EXTREM OTHER THAN JT W/O & W/CONTRAS
73560	RADIOLOGIC EXAMINATION KNEE 1/2 VIEWS
73565	RADIOLOGIC EXAM BOTH KNEES STANDING ANTEROPOST
74000	RADEX ABDOMEN 1 ANTEROPOSTERIOR VIEW
74210	RADEX PHARYNX&/CERVICAL ESOPHAGUS
74240	RADEX GI TRACT UPPER W/WO DELAYED FILMS W/O KUB
74245	RADEX GI TRACT UPR W/SM INT W/MULT SERIAL FLMS
74425	UROGRAPHY ANTEGRADE RS&I
75820	VENOGRAPHY EXTREMITY UNILATERAL RS&I
75894	TRANSCATHETER EMBOLIZATION ANY METH RS&I
75898	ANGRPH CATH F-UP STD TCAT OTHER THAN THROMBYLSIS
75952	EVASC RPR INFRARENAL AAA/DISSECTION RS&I
75960	TCAT STENT ILIAC/LOW EXT ART PRQ/OPN RSI EA VSL
75978	TRANSLUMINAL BALLOON ANGIOPLASTY VENOUS RS&I
75984	CHANGE PRQ TUBE/DRAINAGE CATH W CONTRAST RS&I
75989	RADIOLOGICAL GUIDANCE PRQ DRG W/PLMT CATH RS&I
76000	FLUOROSCOPY SPX UP TO 1 HOUR PHYS/QHP TIME
76098	RADIOLOGICAL EXAMINATION SURGICAL SPECIMEN
76536	US SOFT TISSUE HEAD & NECK REAL TIME IMGE DOCM
76604	US CHEST REAL TIME W/IMAGE DOCUMENTATION
76645	US BREAST REAL TIME W/IMAGE DOCUMENTATION
76700	US ABDOMINAL REAL TIME W/IMAGE DOCUMENTATION
76705	ULTRASOUND ABDOMINAL REAL TIME W/IMAGE LIMITED
76770	US RETROPERITONEAL REAL TIME W/IMAGE COMPLETE
76830	ULTRASOUND TRANSVAGINAL
76856	US PELVIC NONOBSTETRIC REAL-TIME IMAGE COMPLETE
76872	ULTRASOUND TRANSRECTAL
76880	US EXTREMITY NON-VASC REAL-TIME IMG
76937	US VASC ACCESS SITS VSL PATENCY NDL ENTRY
76942	US GUIDANCE NEEDLE PLACEMENT RS&I
76998	ULTRASONIC GUIDANCE INTRAOPERATIVE
77001	FLUORO CENTRAL VENOUS ACCESS DEV PLACEMENT
77055	MAMMOGRAPHY UNILATERAL
77056	MAMMOGRAPHY BILATERAL
77057	SCREENING MAMMOGRAPHY BILATERAL
77080	DXA BONE DENSITY STUDY 1/> SITES AXIAL SKEL
78001	THYR UPTK MLT DETERS
78006	THYR IMG UPTK 1 DETER
78010	THYR IMG ONLY
78018	THYROID CARCINOMA METASTASES IMG WHOLE BODY
78306	BONE &/JOINT IMAGING WHOLE BODY
78452	MYOCARDIAL SPECT MULTIPLE STUDIES
78492	MYOCRD IMAGE PET PERFUS MULTPL STUDY REST/STRESS
78582	PULMONARY VENTILATION & PERFUSION IMAGING
78585	PULM PI PART VNTJ RBRTHING&WSHOT + -1 BRTH
78598	QUANT DIFF PULM PRFUSION & VENTLAJ W/WO IMAGIN

Billing codes include Current Procedural Terminology (CPT), Healthcare Common Procedure Coding System (HCPCS), and hospital-specific billing codes.

Supplemental Table 2 Studies Included in "Other" Category

Billing Code	Description
120	ANESTHESIA EXTERNAL MIDDLE & INNER EAR W/BX NO
142	ANESTHESIA EYE LENS SURGERY
320	ANES ESOPH THYRD LARYNX TRACH & LYMPH NECK 1YR
400	ANES INTEG EXTREMITIES ANT TRUNK & PERINEUM NOS
532	ANESTHESIA ACCESS CENTRAL VENOUS CIRCULATION
790	ANES INTRAPERITONEAL UPPER ABDOMEN W/LAPS NOS
792	ANES LAPS PARTIAL HEPATECTOMY W/MGMT LIVER HEMOR
810	ANES LOWER INTESTINE ENDOSCOPY DISTAL DUODENUM
840	ANESTHESIA INTRAPERITONEAL LOWER ABD W/LAPS NOS
1810	ANES NERVE MUSCLE TDN FASCIA&BURSA FOREARM WRIST
1926	ANES ICRA ICAR/AORTIC THER IVNTL RAD ARTL
1996	DAILY HOSP MGMT EDRL/SARACH CONT DRUG ADMN
11721	DEBRIDEMENT NAIL ANY METHOD 6/>
19125	EXC BREAST LES PREOP PLMT RAD MARKER OPEN 1 LES
19290	PREOP PLACEMENT LOCALIZATION WIRE BREAST
19301	MASTECTOMY PARTIAL
20206	BIOPSY MUSCLE PERCUTANEOUS NEEDLE
20220	BIOPSY BONE TROCAR/NEEDLE SUPERFICIAL
20225	BIOPSY BONE TROCAR/NEEDLE DEEP
20552	INJECTION SINGLE/MLT TRIGGER POINT 1/2 MUSCLES
20610	ARTHROCENTESIS ASPIR&/INJECTION MAJOR JT/BURSA
25000	INCISION EXTENSOR TENDON SHEATH WRIST
26055	TENDON SHEATH INCISION
30903	CONTROL NASAL HEMORRHAGE ANTERIOR COMPLEX
31500	INTUBATION ENDOTRACHEAL EMERGENCY PROCEDURE
31513	LARYNGOSCOPY INDIRECT W/VOCAL CORD INJECTION
31535	LARYNGOSCOPY DIRECT OPERATIVE W/BIOPSY
31575	LARYNGOSCOPY FLEXIBLE FIBEROPTIC DIAGNOSTIC
31579	LARYNGOSCOPY FLX/RGD FIBOPT W/STROBOSCOPY
31599	UNLISTED PROCEDURE LARYNX
31600	TRACHEOSTOMY PLANNED SEPARATE PROCEDURE
33207	INS NEW/RPLC PRM PACEMAKER W/TRANSV ELTRD VENTR
34805	EVASC RPR AAA AORTO-UNIILIAC/AORTO-UNIFEM PROSTH
34812	OPN FEM ART EXPOS DLVR EVASC PROSTH UNI
34813	PLMT FEM-FEM PROSTC GRF EVASC AORTIC ARYSM RPR
35371	TEAEC W/WO PATCH GRAFT COMMON FEMORAL
35476	TRLUML BALLOON ANGIOPLASTY PERCUTANEOUS VENOUS
36011	SLCTV CATH PLMT VEN SYS 1ST ORDER BRANCH
36216	SLCTV CATHJ 1ST 2ND ORD THRC/BRCH/CPHLC BRNCH
36217	SLCTV CATHJ 3RD + ORD SLCTV THRC/BRCH/CPHLC BRNCH
36218	SLCTV CATHJ EA 2ND + ORD THRC/BRCH/CPHLC BRNCH
36223	SLCTV CATH CAROTID/INNOM ART ANGIO INTRCRANL ART
36226	SLCTV CATH VERTEBRAL ART ANGIO VERTEBRAL ARTERY

Supplemental Table 2 Continued

Billing Code	Description
36593	DECLOT BY THROMBOLYTIC AGENT IMPLANT DEVICE/CATH
37191	INS INTRVAS VC FILTR W/WO VAS ACS VSL SELXN RS&I
37204	TCAT OCCLS/EMBOLJ PRQ NON-CNS NON-HEAD/NCK
37205	TCAT PLMT IV STENT PERCUTANEOUS 1ST VESSEL
37207	TCAT PLMT IV STENT OPEN 1ST VESSEL
43262	ERCP W/SPHINCTEROTOMY/PAPILLOTOMY
43264	ERCP W/RMVCALCULI BILIARY&/PANCREATIC DUCTS
43268	ERCP W/INSJ TUBE/STENT BILE/PANCREATIC DUCT
44160	COLECTOMY PRTL W/RMVL TERMINAL ILEUM & ILEOCOLOS
44207	LAPS COLECTOMY PRTL W/COLOPXTSTMY LW ANAST
44213	LAPS MOBLJ SPLENIC FLXR PFRMD W/PRTL COLECTOMY
45331	SIGMOIDOSCOPY FLX W/BIOPSY SINGLE/MULTIPLE
45338	SGMDSC FLX RMVL TUM POLYP/OTH LES SNARE TQ
45380	COLONOSCOPY W/BIOPSY SINGLE/MULTIPLE
45381	COLSC FLX PROX SPLENIC FLXR SBMCSL NJX
45385	COLSC FLX PROX SPLENIC FLXR RMVL LES SNARE TQ
47120	HEPATECTOMY RESCJ PARTIAL LOBECTOMY
47420	CHOLEDOCHOT/OST W/O SPHNCTROTOMY/SPHNCTROP
49180	BX ABDL/RETROPERITONEAL MASS PRQ NEEDLE
49440	INSERT GASTROSTOMY TUBE PERCUTANEOUS
50394	INJECTION PROCEDURE PYELOGRAPHY VIA TUBE/CATH
50398	CHANGE NEPHROSTOMY/PYELOSTOMY TUBE
58100	ENDOMETRIAL BX W/WO ENDOCERVIX BX W/O DILAT SPX
61624	TCAT PERMANENT OCCLUSION/EMBOLIZATION PRQ CNS
62270	SPINAL PUNCTURE LUMBAR DIAGNOSTIC
62318	NJXS INFUS/BOLUS DX/SBST EDRL/SUBARACH CRV/THRC
66984	CATARACT REMOVAL INSERTION OF LENS
67028	INTRAVITREAL NJX PHARMACOLOGIC AGT SPX
69714	IMPLTJ OSSEOINTEGRATED TEMPORAL BONE W/MASTOID
90791	PSYCHIATRIC DIAGNOSTIC EVALUATION
90807	IPI-OB-M/S OFFICE 45-50 MIN MEDICAL E/M
90834	PSYCHOTHERAPY PATIENT &/FAMILY 45 MINUTES
90837	PSYCHOTHERAPY PATIENT &/FAMILY 60 MINUTES
92015	DETERMINATION REFRACTIVE STATE
92071	FIT CONTACT LENS TX OCULAR SURFACE DISEASE
92083	VISUAL FIELD XM UNI/BI W/INTERP EXTENDED EXAM
92133	COMPUTERIZED OPHTHALMIC IMAGING OPTIC NERVE
92134	COMPUTERIZED OPHTHALMIC IMAGING RETINA
92226	OPHTHALMOSCPY EXTENDED RETINAL DRAWING I&R SBS
92235	FLUORESCEIN ANGIOSCOPY INTERPRETATION & REPORT
92250	FUNDUS PHOTOGRAPHY W/INTERPRETATION & REPORT
92511	NASOPHARYNGOSCOPY W/ENDOSCOPE SPX
92540	VSTBLR FUNCJ NYSTAG FOVL&PERPH STIMJ OSCIL TRK
92585	AUDITORY EVOKED POTENTIALS COMPREHENSIVE
92592	HEARING AID CHECK MONAURAL
92626	EVALUATION AUDITORY REHAB STATUS 1ST HR
92960	CARDIOVERSION ELECTIVE ARRHYTHMIA EXTERNAL
92980	TCAT PLMT AN INTRAC STENT PRQ 1 VSL

Supplemental Table 2 Continued

Billing Code	Description
93000	ECG ROUTINE ECG W/LEAST 12 LDS W/I&R
93010	ECG ROUTINE ECG W/LEAST 12 LDS I&R ONLY
93016	CV STRS TST XERS&/OR RX CONT ECG W/O I&R
93018	CV STRS TST XERS&/OR RX CONT ECG I&R ONLY
93282	PROGRAM EVAL IMPLANTABLE IN PERSN 1 LD CARD/DFB
93283	PROGRM EVAL IMPLANTABLE IN PRSN DUAL L CARD/DFB
93306	ECHO TTHRC R-T 2D W/WOM-MODE COMPL SPEC&COLR D
93306	ECHO TTHRC R-T 2D W/WOM-MODE COMPL SPEC&COLR D
93307	ECHO TRANSTHORAC R-T 2D W/WO M-MODE REC COMP
93308	ECHO TRANSTHORC R-T 2D W/WO M-MODE REC F-UP/LMTD
93320	DOPPLER ECHOCARD PULSE WAVE W/SPECTRAL DISPLAY
93321	DOP ECHOCARD PULSE WAVE W/SPECTRAL F-UP/LMTD STD
93325	DOP ECHOCARD COLOR FLOW VELOCITY MAPPING
93350	ECHO TTHRC R-T 2D W/WO M-MODE COMPLETE REST&ST
93454	CATH PLMT & NJX CORONARY ART ANGIO IMG S&I
93459	CATH PLMT L HRT/ARTS/GRFTS WNJX & ANGIO IMG S&i
93508	CATH PLACE C ARTERY FOR ANGRPH W/O LEFT CATHJ
93510	L HRT CATHETERIZATION RETROGRADE BRACHIAL PERQ
93539	NJX PX DURING C-CATHJ SLCTV OPACIFICJ CONDUITS
93540	NJX PX C-CATHJ SLCTV OPACIFICJ BPG 1 + C ART
93543	INJECTION CARDIAC CATHJ L VENTR/L ATR ANGIOGRAPH
93545	NJX PX C-CATHJ F/SLCTV C ANGRPH
93555	I SI&R F/NJX PX DURING C-CATHJ VENTR&/ATR ANGRPH
93556	I SI&R F/NJX PX DURING C-CATHJ PULM&/OR SELECT
93880	DUPLEX SCAN EXTRACRANIAL ART COMPL BI STUDY
93922	NON-INVAS PHYSIOLOGIC STD EXTREMITY ART 2 LEVEL
93924	N-INVAS PHYSIOLOGIC STD LXTR ART COMPL BI
93926	DUP-SCAN LXTR ART/ARTL BPGS UNI/LMTD STUDY
93970	DUP-SCAN XTR VEINS COMPLETE BILATERAL STUDY
93971	DUP-SCAN XTR VEINS UNILATERAL/LIMITED STUDY
93975	DUP-SCAN ARTL FLO ABDL/PEL/SCROT&/RPR ORGN COM
93978	DUP-SCAN AORTA IVC ILIAC VASCL/BPGS COMPLETE
95870	NEEDLE EMG LMTD STD MUSC 1 XTR/NON-LIMB UNI/BI
95885	NEEDLE EMG EA EXTREMITY W/PARASPINL AREA LIMITED
95886	NEEDLE EMG EA EXTREMTY W/PARASPINL AREA COMPLETE
95900	NRV CNDJ AMPLT&STD EA NRV MOTOR W/O F-WAVE STD
95903	NRV CNDJ AMPLT&STD EA NRV MOTOR W/F-WAVE STD
95904	NRV CNDJ AMPLT&STD EA NRV SENS
95910	MOTOR &/SENS 7-8 NRV CNDJ PRECONF ELTRODE LIMB
99999	DERM NO CHARGE
99999	DERM NO CHARGE
1123F	ADV CARE PLN TLKD & ALT DCSN MAKER DOCD

Supplemental Table 2 Continued

Billing Code	Description
2010F	VITAL SIGNS RECORDED
3120F	12-LEAD ECG PERFORMED
6030F	ALL ELEM OF MAX STERILE BARRIER TECHNQ FLLWD
EM002	NO CHARGE
G0008	ADMINISTRATION OF INFLUENZA VACCINE
G0278	ILIAC ARTERY ANGIOGRAPHY PRFRMD TH SM TME OF CRDAC CHTHRZTN
G0431	Drug screen, qualitative
G8704	12-LEAD ELECTROCARDIOGRAM PERFORMED
J3420	INJECTION VITAMIN B-12
J7030	INFUSION - NORMAL SALINE SOLUTION 1000CC
V5267	HEARING AID SUPPLIES/ACCESSORIES

Billing codes include Current Procedural Terminology (CPT), Healthcare Common Procedure Coding System (HCPCS), and hospital-specific billing codes.