The Effect of Imaging Capacity on the Imaging Workup of Patients With Stroke: A Preliminary Case for a Cross-Country Comparison

Max P. Rosen, MD, MPH[a], Natalie Oake, MSc[b,c], Alan J. Forster, MD, MSc[b,c,d], Ari Goelman, PhD[e], Frank Levy, PhD[f]

Purpose: Medical imaging is a large and growing component of health care expenditures. To better understand some of the determinants of imaging ordering behavior, the authors analyzed the effect of differential capacity on the imaging workup of patients with acute nonhemorrhagic stroke.

Methods: All patients at a US teaching hospital and a two-campus Canadian teaching hospital between 2001 and 2005 discharged with diagnoses of acute nonhemorrhagic stroke were identified. Billing data were linked with clinical information systems to identify all imaging studies performed, comorbidities, and patient disposition.

Results: Nine hundred eighteen patients at the US hospital and 1,759 patients at the Canadian hospital were included. Patients were similar in age and distribution of comorbid illnesses. The rate of MRI scans at the US hospital was more than twice that at either of the Canadian hospitals (95.75 scans per 100 patients vs 41.39 scans per 100 patients). The length of stay was significantly shorter and the inpatient mortality rate significantly lower at the US hospital compared with the Canadian hospital. A multivariate regression analysis demonstrated that only patient age and site (US vs Canada) were significant predictors of MRI use, controlling for patient gender, comorbidities, and use of anticoagulants.

Conclusions: Scanning utilization varied at hospitals with differential access to scanning technologies. There was less frequent use of MRI scanning at hospitals with limited access to this modality. Patient and health system factors are important considerations when interpreting the mechanisms for this variation, its importance, and the potential relationship of imaging use with patient outcomes.

Key Words: CT, MR imaging, stroke, comparative studies, outcomes analysis, technology assessment

J Am Coll Radiol 2011;8:428-435. Copyright © 2011 American College of Radiology

INTRODUCTION

Advanced medical imaging is a large and growing component of rising US health care expenditure. Between 2000 and 2006, advanced imaging payments (for CT, MR, and PET) under the Medicare Physician Payment Schedule rose from $6.9 billion to $14.1 billion [1]. This growth rate, 102% over 6 years, was roughly twice the rate of growth of total US health care spending [2]. By 2005, imaging already accounted for one-fifth of all physician payments under the Medicare Physician Payment Schedule [3].

Although there are many potential reasons for this growth (reducing physician uncertainty, fear of litigation, and individual financial incentives [4] and patient demand [5]), one of the major drivers of utilization in the United States may be excess imaging capacity available in most major metropolitan areas. As the mysterious voice in *Field of Dreams* tells Ray Kinsella, "If you build it, he will come."

In Canada, however, limited provincial budgets lead to restricted capacity compared with the United States.

[a]Department of Radiology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts.

[b]The Ottawa Hospital, Ottawa, Ontario, Canada.

[c]Ottawa Hospital Research Institute, Ottawa, Ontario, Canada.

[d]University of Ottawa, Faculty of Medicine, Department of Medicine, Ottawa, Canada.

[e]School of Business, Kwantlen Polytechnic University, Surrey, British Columbia, Canada.

[f]Massachusetts Institute of Technology, Cambridge, Massachusetts.

Corresponding author and reprints: Max P. Rosen, MD, MPH, Department of Radiology, Beth Israel Deaconess Medical Center, Harvard Medical School, 330 Brookline Avenue, Boston, MA 02215; e-mail: mrosen2@bidmc.harvard.edu.

Dr Levy's work was supported by an Investigator Award from the Robert Wood Johnson Foundation (Princeton, NJ).

0091-2182/11/$36.00 • DOI 10.1016/j.jacr.2011.02.012

For example, in 2005, Canada had 11.3 CT scanners per million people, compared to 32.2 CT scanners per million people in the United States [6, p17]. The Canadian CT figure ranked below the Organisation for Economic Co-operation and Development median of 13.8 CT scanners per million people [6, p17]. Although Canadian scanning capacity remains limited, this capacity did increase sharply in the early part of the decade. From 1990 to 2006, the number of Canadian CT scanners increased by 180 (91%), while the number of Canadian MR scanners increased by 177 (932%) [6, p17].

The US-Canadian disparity in MRI scanners is much larger: 5.5 scanners per million people in Canada in 2005 compared with 26.6 scanners per million people in the United States in 2004 [6, p18]. In sum, compared with a typical US physician, a typical Canadian physician must deal with relatively limited total scanning capacity, in particular limited MRI capacity.

In this study, we used administrative databases from a Canadian and a US teaching hospital (both in major metropolitan areas) to conduct a preliminary examination of how Canadian-US differences in scanning capacity may shape imaging utilization. Our primary purpose was to investigate if US-Canadian differences in CT and MRI capacity are associated with different imaging utilization patterns for a single patient population. For this purpose, we chose to study patients presenting to the emergency department who had discharge diagnoses of first episodes of acute, nonhemorrhagic stroke. We chose this patient population because it could be easily and distinctly identified via administrative databases. We also used these data to compare length of stay and mortality among patients treated at these two institutions.

METHODS

Study Design and Setting

We conducted a retrospective cohort study using deidentified administrative and clinical databases from Beth Israel Deaconess Medical Center (the US hospital) and The Ottawa Hospital (the Canadian hospital). The US hospital is a teaching hospital of Harvard Medical School and is located in Boston, Massachusetts. It has approximately 600 licensed beds and 1,200 physicians on the active medical staff and is one of several major academic medical centers in a metropolitan region of approximately 5.7 million people. During the study period, the US hospital had approximately 38,000 to 39,000 discharges per year, with an average occupancy rate of approximately 80%. The average case mix index was 1.41. The Ottawa Hospital is a teaching hospital of the University of Ottawa and is located in Ottawa, Ontario, Canada. The Canadian hospital has two inpatient care campuses with 950 licensed beds and 1,250 physicians on the active medical staff. It is the largest adult referral center within a region of approximately 1.1 million people. During the study period, there were an average of 44,000 to 45,000 discharges per year, with an average occupancy rate of approximately 100%. Data on case mix index were not available.

Because the Canadian hospital is the major institution in the area, it is likely that it captured most, if not all, patients with acute stroke. At the US hospital, there are 8 emergency departments that are designated to have primary stroke services. The emergency medical service triages patients to the nearest stroke facility.

At the time of this study, the US hospital had an acute stroke protocol in place (Appendix 1). The US hospital had 6 MRI scanners and 7 CT scanners. Both MRI and CT were available 24 hours per day, 7 days per week. Unlike the US hospital, the Canadian hospital did not have a stroke protocol at the time of this study. The Canadian hospital had 2 MRI scanners and 5 CT scanners. MRI was available 24 hours per day Monday to Friday and 8 hours per day on Saturday and Sunday. CT was available 16 hours per day Monday to Friday and 8 hours per day on Saturday and Sunday.

The US portion of this study was exempt from institutional review board approval because the data were deidentified and used in aggregated form. The Canadian portion of the study was approved by the Canadian hospital's research ethics board.

Data Sources

We used 3 US hospital administrative databases. The discharge abstract database records details of inpatient and outpatient encounters including patient demographics, diagnoses, and pharmacy services. The admissions, discharges, and transfers database identifies if patients were transferred to the US hospital from acute care hospitals. The radiology information system database records the date and time and description of radiologic services received by patients. The 3 databases were linkable using a common patient encounter identifier.

The Canadian hospital data were extracted from the Canadian hospital's data warehouse. The data warehouse contains information from the hospital's patient registration system, the clinical data repository (containing laboratory, pharmacy, radiology, and clinical notes), and the discharge abstract database (which summarizes demographic, diagnostic, and procedural information for each inpatient admission). Ultrasound studies conducted at one of the two Canadian campuses were excluded from the analyses because these imaging tests are not captured in the data warehouse. Similar to the US hospital data, tables in the data warehouse were linkable using a common identifier.

Study Eligibility Criteria

Inpatient admissions via the emergency department between October 1, 2002, and December 31, 2006, were eligible for both the US and Canadian hospitals, if the discharge abstract indicated a most responsible diagnosis