Computed Tomography Use in a Tertiary Care University Hospital

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Purpose: Improvements in computed tomography (CT) technology, with shorter scan times and better image quality, have contributed to an increase in the use of CT in the United States in recent years. This increased use has implications for health policy and radiation risk assessment. The purpose of this study was to evaluate trends in CT use.

Methods: The CT performance records at a university-based, tertiary care, level 1 trauma center hospital were evaluated from 1998 to 2005. The hospital's decision support infrastructure was used to track overall patient visits and stays. From these data sets, the age and sex dependency of CT use rates were evaluated for outpatients, inpatients, and emergency department (ED) patients.

Results: Outpatient use rates averaged over the age groups of 21 to 30 years, 41 to 50 years, and 61 to 70 years were 20, 59, and 87 CT scans per 1,000 outpatient visits, respectively. Inpatient use rates for these same age groups were 88, 148, and 162 CT scans per 1,000 inpatient days, respectively. ED patient use rates for these same age groups were 705, 687, and 394 CT scans per 1,000 ED patient visits, respectively. Male patients outnumbered female patients for both ED and inpatient CT use from the early teens to the mid-40s age range.

Conclusion: The overall CT use increased 27% and 48% from 2000 to 2004 for outpatient and inpatient visits, respectively. CT use in the hospital's high-volume ED increased 131% from 2000 to 2004, which may be partly attributable to the installation of 2 CT scanners near the ED.

Key Words: Computed tomography, radiology practice, emergency medicine

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INTRODUCTION

National trends suggest that computed tomography (CT) use is rapidly growing [1-4]. This is a source of concern to the radiology community from the perspective of increased cost and increased radiation dose to the patient population. CT is already known to be the greatest source of the collective radiation dose in the United States, and approximately 75% of radiation exposure (excluding background sources) in the United States has been attributed to CT [5]. For these reasons, detailed analysis of CT use in clinical practice may be valuable for identifying the underlying factors that are driving these increases in use. Such data are particularly important in the face of the recent clinical deployment of extreme multislice (64+ slices) CT scanners, which will likely cause further increases in CT use because of additional clinical applications, such as cardiothoracic imaging.

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Databases in the Radiology Information System (RIS) (IDX Imagecast, Burlington, Vermont) and hospital records system at the University of California, Davis Medical Center were used to study trends in CT use during a period from 1999 to 2004. These trends included the age and sex distribution of patients undergoing CT procedures in the outpatient, inpatient, and emergency department (ED) settings, normalized to the calendar year 2004. The purpose of this study was to evaluate the trends in CT use for the University of California, Davis Medical Center, which is typical of a large urban academic center with a large ED service.

METHODS AND MATERIALS

Data Acquisition and Analysis

The RIS database at the University of California, Davis Medical Center was queried for all CT studies performed from July 1998 to December 2005. More than 286,000 CT scans were performed during this 7.5-year timeframe. Data retrieved included the patient's medical record number, date of birth, date of the CT study, gender, and *Current Procedural Terminology* (*CPT*®) code, which indicates the type of CT procedure (eg, head, abdomen). Patient age at

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the time of the CT study was tallied with a resolution of one year. CT scans were tallied per CPT code, although the individual CPT codes were not evaluated. In most cases, patients underwent several CPT code-defined procedures at one setting, for example, an abdomen and pelvis study performed simultaneously. The research comprised by this study was a retrospective analysis of patient records and was conducted under an existing internal review board protocol (approved January 19, 2005). Patient consent was not required.

Although the CT scan data were available from July 1998 to December 2005, the 1998 data were not used in the trend analysis because they were only for a partial year. Although the 2005 data were available, a change of the RIS system during this year led to changes in how inpatient, outpatient, and ED patient data were tallied, so to be consistent, the 2005 data were excluded from the annual trend analysis.

The 1999 data were used for long-term trend analysis; however, to reflect more recent trends in use, the 2000 to 2004 data were used for age-based metrics. The distribution of patient age at the time of CT study is important because of the age dependency of radiation risk. For the CT scan database, the age distribution in the calendar year 2004 was compared with the age distribution of each year from 2000 to 2003, and no significant differences were found (P values ranged from .31 to .81, Wilcoxon signed-rank test). Thus, the data during this 5-year period were summed and then renormalized to the 2004 patient volume. This procedure allowed us to leverage the larger patient count during the 2000 to 2004 time frame to reduce statistical fluctuations, while analyzing trends for the 2004 calendar year.

The hospital decision support system (PowerBuilder, Sybase, Dublin, California) was used to tally the number of patients classified as inpatients, outpatients, and ED patients from 1999 to 2004. The ED and outpatient data were tallied as patient visits, whereas the inpatient data were tallied as the product of *patient* $\times$ *hospital stay duration* ("patient-days"). Both metrics were used to normalize the CT use data. The database was also used to evaluate the age and sex distribution of the hospital's patient population; however, the age and sex breakdowns were only available during the 2003 to 2005 period. The age distribution was tallied with a resolution of one year.

One of the principle focuses of this study was to better understand the age dependencies in CT use; however, the age-specific data for the 2 data sets (CT use and hospital visitations) were available for 2 slightly different time periods (1999-2004 for CT use and 2003-2005 for patient hospital statistics). To accommodate these differences, the age categories were summed for the CT data set over the years 2000 to 2004 and rescaled to the overall number of scans in 2004. The patient visitation data were summed for the 2003 to 2005 period in each age category and rescaled in terms of overall patient visits in 2004. This weighted averaging was used to reduce the statistical fluctuations in the age categories; however, by prorating both data sets to the same year, consistent use statistics could be determined. Noise reduction per age category is particularly important in computing the ratio (CT scans per patient visits), a process that amplifies noise in the data.

U.S. Census Bureau data for the calendar year 2004 were accessed on the Internet [6], and the age distribution of the local population was used in this study. These population data were categorized in nonuniform age intervals (eg, 0-4 years, 5-9 years, 25-34 years); thus, multiyear data averaging was necessary for comparison with the census data.

Computer programs custom written in C (Microsoft Corporation, Redmond, Washington, C/C++ 6.0 service pack 5) were used to extract and evaluate the data from the RIS system. Processed data were also evaluated using a commercially available spreadsheet (Excel, Microsoft Corporation).

All graphs with age as the abscissa used 3-element boxcar averaging to reduce statistical noise in the presentation.

Clinical Setting

The University of California, Davis Medical Center is a large tertiary care facility serving the metropolitan and outlying areas of Sacramento, California. The population of the Medical Center's surrounding 4-county metropolitan area in 2005 was 1.93 million. The institution is a level 1 trauma center and is 1 of the 5 busiest trauma centers in the United States. The university runs a number of outlying clinics in the suburban areas surrounding the central city area; however, there are no CT scanners associated with these clinics, and visits to the clinics were not included in the tallies reported here. Some fraction of the clinic patients are referred to the main medical center for their imaging needs, and this may enrich (increase) the outpatient imaging use rates reported here.

In the calendar year 2004, the institution ran a total of 5 CT scanners, including one in an on-campus outpatient facility (a 4-detector row scanner, General Electric, Waukesha, Wisconsin), one that is associated with a positron emission tomography system (a 16-detector row scanner, General Electric Discovery, Waukesha, Wisconsin), and a 4-detector row system (Toshiba Aquilion; Toshiba Inc, Tokyo, Japan) in the main hospital. Two 16-detector row scanners (General Electric) are located in the main hospital, immediately adjacent to the ED, and these 2 systems were installed together in March 2003.

RESULTS

Between 1999 and 2005, 286,753 CT procedures were performed on 99,661 unique patients (Figure 1). Figure