The American Journal of Surgery (2016) 211, 908-912

The American Journal of Surgery®

North Pacific Surgical Association

A statewide teleradiology system reduces radiation exposure and charges in transferred trauma patients

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KEYWORDS:
Teleradiology;
Radiation;
Reduction;
Decreased;
Charges;
Statewide

Abstract

BACKGROUND: Trauma transfer patients routinely undergo repeat imaging because of inefficiencies within the radiology system. In 2009, the virtual private network (VPN) telemedicine system was adopted throughout Oregon allowing virtual image transfer between hospitals. The startup cost was a nominal $3,000 per hospital.

METHODS: A retrospective review from 2007 to 2012 included 400 randomly selected adult trauma transfer patients based on a power analysis (200 pre/200 post). The primary outcome evaluated was reduction in repeat computed tomography (CT) scans. Secondary outcomes included cost savings, emergency department (ED) length of stay (LOS), and spared radiation. All data were analyzed using Mann–Whitney *U* and chi-square tests. *P* less than .05 indicated significance. Spared radiation was calculated as a weighted average per body region, and savings was calculated using charges obtained from Oregon Health and Science University radiology current procedural terminology codes.

RESULTS: Four-hundred patients were included. Injury Severity Score, age, ED and overall LOS, mortality, trauma type, and gender were not statistically different between groups. The percentage of patients with repeat CT scans decreased after VPN implementation: CT abdomen (13.2% vs 2.8%, $P < .01$) and cervical spine (34.4% vs 18.2%, $P < .01$). Post-VPN, the total charges saved in 2012 for trauma transfer patients was $333,500, whereas the average radiation dose spared per person was 1.8 mSV. Length of stay in the ED for patients with Injury Severity Score less than 15 transferring to the ICU was decreased ($P < .05$).

CONCLUSIONS: Implementation of a statewide teleradiology network resulted in fewer total repeat CT scans, significant savings, decrease in radiation exposure, and decreased LOS in the ED for patients with less complex injuries. The potential for health care savings by widespread adoption of a VPN is significant.

In the United States, approximately 2.2 million patient transfers occur between emergency departments (EDs) each year.[1] Most of these transfers are from smaller, rural

The authors declare no conflicts of interest.

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Manuscript received November 3, 2015; revised manuscript January 19, 2016

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http://dx.doi.org/10.1016/j.amjsurg.2016.01.010

community hospitals to larger regional medical centers for advanced interventional and supportive care. Studies show a high degree of variability with the incidence of pre-transfer computed tomography (CT) imaging of trauma transfer patients ranging from 14% to 75%.[2–4] In 2007, the *New England Journal of Medicine* reported concerns related to increasing radiation imaging exposures including increased health care system costs and individual cost- and radiation-related complications increasing cancer risk and contrast nephropathy.[1–9] This study aims to evaluate the current utility, cost savings, and reduction of radiation exposure associated with implementation of a statewide teleradiology system.

An estimated 62 million CT scans were performed in the United States in 2007, a 3-fold increase in the last decade alone.[5] Radiation dosing is calculated by the energy absorbed per unit of mass and is measured in grays (Gy) and often reported in Sieverts or millisieverts (mSv). A typical abdominal CT scan exposes a patient to approximately 100 times more radiation than a conventional chest x-ray.[5,8] Increased radiation exposure can cause DNA breaks or damage creating hydroxyl radicals that interact with water molecules.[5] Although radiation-induced damage is often repaired, point mutation, translocations, and fusions do occur. These DNA alterations can lead to induction of cancer, with one Sievert of absorbed radiation increasing a patient's lifetime risk of cancer by 5.5%.[9]

Risks of repeat imaging have led to localized efforts at improving inter-hospital image transfer efficacy. This can involve transferring images through CD or picture archiving communication system. Delivery through CD is often problematic resulting in inability to open the imaging files because of software incompatibility or lost CDs requiring repeat imaging. Electronic transfer of imaging through teleradiology allows more timely patient care, decreased radiation exposure, and also prevents administration of a second dose of intravenous contrast.[1,2,6]

In 2007, Oregon Health and Science University (OHSU) implemented a statewide teleradiology system termed virtual private network (VPN). This software allows secure interhospital transfer of patient information including imaging. At inception, VPN was easily adopted statewide for less than $3,000 per hospital and has been especially useful in treating trauma transfer patients from across the state. By 2009, all but one hospital had established a VPN system. We hypothesized that implementation would lead to decreased ED length of stay (LOS), decreased overall system cost, reduced repeat imaging studies, and radiation exposure in critically injured patients.

Methods

A retrospective chart review of OHSU's trauma registry databases was performed from 2007 to 2012 with institutional review board approval. A power analysis was performed using a test comparing 2 proportions being able to detect a difference of a decrease in CTs from 20% to 10% using an alpha of .05 and a power of 80% requiring a sample size of 200 per group. Two hundred trauma transfer patients admitted before the implementation of VPN and 200 patients post-VPN were included. These 400 patients were chosen randomly from a list of all OHSU trauma transfer patients (n = 3,897) from 2007 to 2012 using the randomization tool in SPSS (IBM, Armonk, NY). Patient demographics (age, sex, and Injury Severity Score [ISS]) were compared between groups. Analysis remained stratified into 2 groups based on their date of admission: 2007 to 2008 or 2009 to 2012. The Mann–Whitney U test was used to assess all nonparametric continuous data. The chi-square tests were used to assess all categorical data. Significance was set as P less than .05.

A chart review was conducted to determine the type of CT scan performed (chest, abdomen, pelvis, cervical/thoracic/lumbar spine, and/or extremity). To identify and determine the utility of the VPN system, patients were broken into the following groups: (1) those who had a CT at the referring facility but not OHSU and (2) those who had a CT at both institutions. The primary outcome was overall reduction in number of repeat CT scans differentiated by body region. Secondary outcomes included cost savings, ED LOS before ICU transfer, and spared radiation dosing.

Variables used in calculating data included radiation doses and health care cost. Utilizing a recent literature review, the effective dose of radiation per CT scan was estimated to be near 6 to 8 mSv depending on the type of scan.[7,8] Charges were obtained using the most up-to-date CPT coding sheets for OHSU department of radiology for CT scan without contrast. Total charges included the CT scan, technician fee, and professional reading fee.

The likelihood of receiving an outside CT scan was calculated for each body region. The number of scans saved per body region was calculated using the percentage decrease of those receiving a repeat scan among all patients who received an outside CT. Spared radiation dose was calculated using a weighted average of dose spared per region with the likelihood of a CT in that region. Charges were calculated per 100 patients using a weighted average of charges saved per region with the likelihood of a CT in that region. Total savings were calculated using this weighted average and then applied to the 826 trauma transfer patients OHSU received in 2012.

Results

Comparing patient characteristic variables between the 2 groups of 400 randomly selected patients, there was no difference in ISS, age, ED and overall LOS, mortality, trauma type, and gender (Table 1). In all but one region, there was a downward trend in the number of repeat CT scans performed after implementation of VPN (Table 2). Comparing incidence between pre- and post-VPN groups, there was a significant reduction for patients who