Using the Internet for Image Transfer in a Regional Trauma Network: Effect on CT Repeat Rate, Cost, and Radiation Exposure

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Purpose: The aims of this study were to evaluate an Internet-based and compact disc-based image transfer system and to compare this system with others in the literature, specifically regarding effects on repeat imaging rate, cost, and radiation dose to patients transferred to a level I regional trauma center.

Methods: Five hundred consecutive trauma patients transferred to a level I trauma center between June 1 and July 15, 2009, were included in the study. Images were transferred from an outside facility to the trauma center using the Internet and compact discs and uploaded to the trauma center's PACS. Radiographic studies and CT scans at the trauma center were classified as outside studies, completion studies, or repeat studies. Repeat rate, costs, and radiation doses of transferred and repeated CT scans were calculated.

Results: Four hundred ninety-one patients met the inclusion criteria. The patients' average age was 40.5 years, and 70% were men. The average Injury Severity Score was 14.7. Three hundred eighty-three patients had 852 CT studies and 380 nonextremity radiographs imported into the trauma center's PACS. At the trauma center, 494 completion CT scans and 2,924 radiographic studies were performed on these patients. Sixty-nine repeat CT scans were performed on 55 patients, equalling a 17% repeat rate. The total value of imported CT studies was $244,373.69. Repeat imaging totaled $20,495.95, or $84.65 per patient with transferred CT studies.

Conclusions: Using a combination of the Internet and compact discs to transfer images during inter-hospital transfer is associated with much lower repeat rates than those in the literature, suggesting that regional PACS networks may be useful for reducing cost and radiation exposure associated with trauma.

Key Words: Image sharing, PACS, cost, radiation dose, trauma, teleradiology

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INTRODUCTION

Utilization rates of CT in emergency departments (EDs) have more than doubled over the past decade, accompanied by increasing health care costs and medical radiation exposure [1,2]. In 2006, it was estimated that CT contributed to nearly half of all medical radiation exposure [3]. Because of the regionalization of trauma networks, patients often transfer between health care facilities to receive definitive care [4]. In these critically ill and extensively imaged transferred trauma patients, CT repeat rates of 29% to 58% have been observed [5-7].

In 2000, it was estimated that repeated laboratory and imaging resulted in an additional cost of $600 per transferred trauma patient [8], a figure likely to have increased substantially since. The American College of Emergency Physicians recommends that when patients transfer between one ED and another hospital, an appropriate medical summary and other pertinent records should accompany the patient or be transferred electronically [9]. The most widely used means of radiology image transfer in the United States are compact discs (CDs) [7,10]; however, CDs arrive with, not before patients and are sometimes incompatible with the receiving hospital's PACS. Moreover, the time taken to generate a CD and upload it

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to the receiving hospital's PACS may further delay transfer and definitive care. Teleradiology has been suggested as a means of evaluating the scans of transfer patients while they are still at the outside hospital, thereby reducing the number of unnecessary referrals [11-13]. Unnecessary reimaging adds extra cost, time, and potentially extra radiation and iodinated contrast exposure to patients [5-7]. The use of the Internet or teleradiology for image transfer and its effect on reimaging has not been evaluated.

Improvement of the IT infrastructure is now accelerated by the Health Information Technology for Economic and Clinical Health Act of 2009, which provides incentives for the implementation and adoption of electronic health records among institutions and providers [3] and encourages health information exchange [14]. PACS are used by nearly 90% of academic medical centers and hospitals with >200 beds [15]. Despite this, there has been little interinstitutional consolidation of patient imaging records in the medical IT infrastructure, or consolidation of data so that they are accessible anywhere [10].

The development of regional image transfer networks offers a potential solution for many of these problems [10,16,17]. The Integrating the Healthcare Enterprise Cross Enterprise Document Sharing Profile has been developed, in part, as a way to allow one PACS or workstation to access patient image data stored on PACS at hospitals in a whole region [17]. Another means is to create an extensive Internet-based virtual private network with direct connections between outside hospitals and a receiving hospital. Our trauma center uses the latter approach but also supports the importation of radiology on CDs directly into the PACS in our ED.

Previous studies investigating repeat CT rates in transferred trauma patients have not had the capability to electronically transfer images via the Internet [5-7]. The purpose of this study was to evaluate the use of the Internet and immediate CD importation to transfer images to a level I regional trauma center on imaging repeat rate, cost, and radiation dose and compare this with previously published repeat rates, all of which are from trauma centers without the capability to electronically transfer images.

METHODS

Study Design and Setting

This retrospective cohort study was performed at a level I adult and pediatric trauma center that receives 6,000 polytrauma patients per year. As the sole level I trauma center for 25% of the land area of the United States, Harborview Medical Center (HMC) receives about 3,300 transferred trauma patients from outside acute care facilities every year. The institutional review board approved this study, waiving the need for written informed consent.

Infrastructure

At the time of the study, there were 109 referring community hospital and radiology practices that could transfer images to HMC via the Internet using a secure virtual private network system (Figure 1). Memoranda of understanding existed between these "outside hospitals" and HMC to ensure compliance with HIPAA. Images were transferred to HMC for the purposes of continuing care of the trauma patients.

As shown in Figure 2, all trauma patient transfers coming to HMC are processed by a centralized "transfer center" that is contacted by the outside hospital through a toll-free telephone number. The transfer center coordinates all aspects of patient transfer, including the transfer of outside imaging with the patient, via CD, printed film, or the Internet. The transfer center encourages the use of the Internet when the referring hospital has it available. Images sent from outside PACS are received at HMC on a separate PACS, installed specifically for the purpose of receiving images via the virtual private network (GE Centricity RA-600; GE Healthcare, Waukesha, Wisconsin), where they are stored temporarily. An electronic "whiteboard," accessible using the HMC intranet, is used to track the progress of outside images arriving via the RA-600 system. For trauma patients whose transfer is under way, the images are automatically transferred from the RA-600 system to the main HMC PACS (GE Centricity RA-1000 version 2.1; GE Healthcare) so they are available throughout our institution. This process is usually complete before the patient arrives at the trauma center.

For patients arriving from centers without virtual private network connections, a CD is the preferred means of image transfer. When CDs arrive with patients, the images are uploaded to the HMC PACS (RA-1000) in the emergency radiology area using a desktop computer and image viewing software (DICOM Open Lite Box 2.7; Sorna Corporation, Eagan, Minnesota).

Communicating CT Imaging Standards to the Community

Before the commencement of this study, guidelines for minimum CT imaging standards for trauma examinations were developed by the HMC radiology department and distributed to radiology departments in the region. The Washington State Radiological Society and the regional trauma network were used to communicate these imaging standards, and these were put on our departmental Web site for open access. The HMC radiology department indicated that if a patient underwent a CT study that met these standards, the study would not be repeated at the trauma center unless indicated for a change in clinical status.

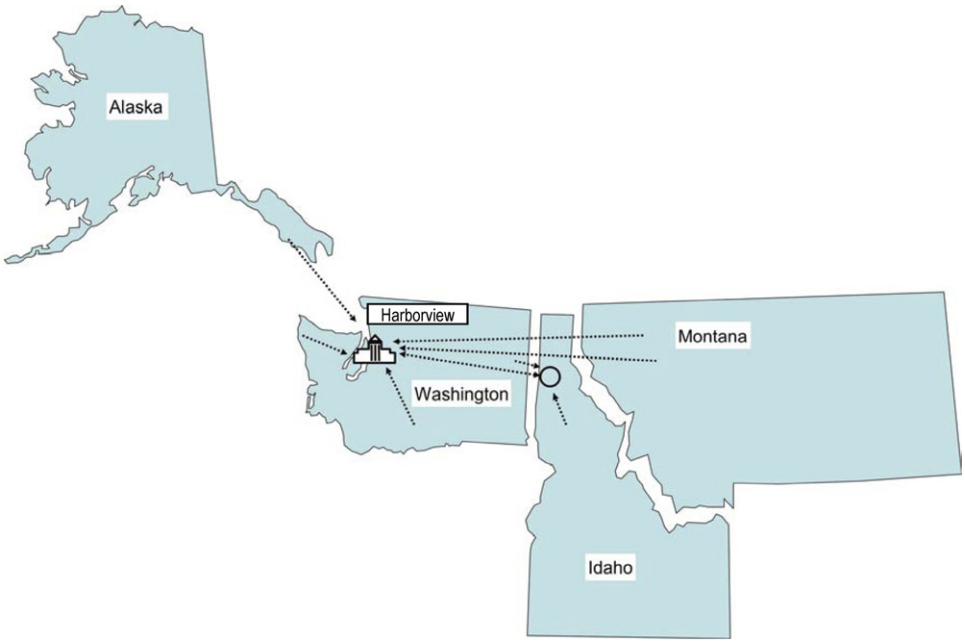

Fig 1. Schematic of the virtual private network image transfer system. Harborview Medical Center is the only level I regional trauma center for 4 states. Both unidirectional and bidirectional (double-headed arrow) connections exist between outside facilities and HMC. Some private practice groups have hubs (white circle), which connect individual facilities together. These hubs have links with Harborview. For clarity, only a small fraction of the connections are shown. The map is not to scale.

Patient Selection

Using the electronic log of patients transferred through the HMC transfer center, we identified 500 consecutive trauma patients who were transferred from an initial assessing hospital ("outside institution") to our institution between June 1 and July 15, 2009. Nontrauma transfers were excluded from the study. Patients had to arrive at HMC within 48 hours of their arrival at the outside institution, otherwise these patients were considered to be nonacute and were excluded from the study.

Data Collection and Analysis

We reviewed the PACS log to identify all CT and radiographic studies performed on each transfer patient at the outside institution and transferred into the PACS, and all imaging performed at the trauma center.

All imaging was then classified as "outside" or "local" studies. An outside study (radiography or CT) was defined as a study performed at an outside institution and transferred to the trauma center PACS. Outside studies included those that were transferred using either the Internet or CDs.

A local study was any CT or radiographic examination performed in the HMC ED. All patients arriving from outside hospitals go through the HMC ED, where all imaging is performed before the patient is sent to the intensive care unit, admitting service, or operating room. Local studies were subclassified into "completion studies" and "repeat studies."

A completion study was defined as a local study of a different body region to the outside study. Completion studies also included imaging of the same body region and modality as the outside imaging if the repeat imaging was performed for a change in clinical status or for follow-up imaging for a finding recognized on the outside study (eg, a second CT study of the hip joint to identify intra-articular bone fragments after closed reduction of a fracture-dislocation of the hip). Because it is standard protocol to perform repeat head CT at HMC on patients with traumatic intracranial hemorrhage 6 hours after the initial CT scan, a CT scan performed >3.5 hours after the initial head CT scan was classified as a completion study. Head CT performed <3.5 hours after the initial outside head CT scan would be classified as a repeat CT study.

A repeat study was defined as a local study performed after an equivalent outside study of the same modality was performed, not meeting criteria for a completion study.

Injury Severity Scores (ISS) were obtained from the hospital trauma registry. Injury Severity Scores are used to assess trauma severity and correlate with mortality, morbidity, and hospitalization.

Where possible, the reason repeat CT studies were performed was determined by examining the request

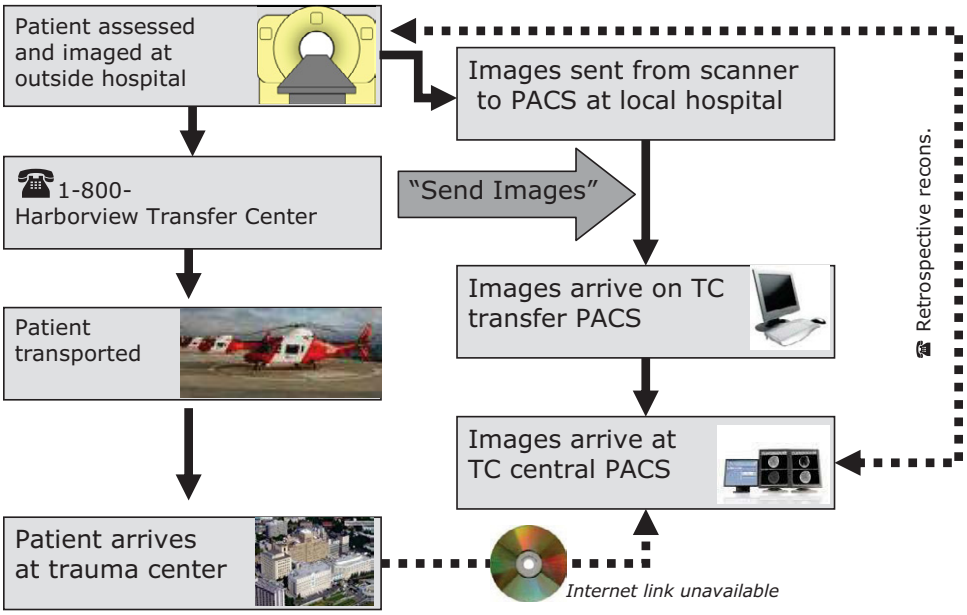

Fig 2. Workflow for transfer of outside images to Harborview Medical Center (HMC). Patients arriving at an outside hospital are assessed, and imaging (usually radiography and CT) is performed. Immediately after the imaging is complete, the outside facility can send the images to the transfer PACS at HMC using the Internet. All patient transfers to the trauma center (TC) are directed through the HMC transfer center, where the referring hospital discusses the case with the receiving trauma team. The transfer center handles all aspects of transfer and instructs the outside hospital to send images using the Internet to HMC if they have not already done so. The transfer center organizes for the outside images to be transferred from the transfer PACS to the HMC central PACS while the patient is in transit. If there is no virtual private network link between HMC and the outside facility, compact discs or films are sent with the patient. These are uploaded into the HMC PACS in the emergency department immediately after patient arrival. If the radiologist reviews the images and deems that further reconstructions from source CT data are necessary, he or she can phone the outside facility and request "retrospective reconstructions" that can be forwarded via the Internet.

form, the CT images in the PACS, and clinical records. If the request clearly stated the reason for repeat imaging, this was recorded. If the outside CT study was inferior to the trauma center's outside CT standards, it was assumed to be the reason for the repeat study. The reason for repeat radiography was not determined because the radiology department has no minimum standards for acceptable quality of outside radiographs.

Radiographs were excluded from the radiation dose and cost savings components of this study because of the variable cost of each radiograph, comparatively low radiation dose, and difficulty in determining whether repeat radiographs were clinically indicated.

Cost and Radiation Savings

The "cost" of CT scans was approximated by combining both the professional and technical reimbursement rates using CMS published rates for 2009 for Washington State. Published values for radiation effective doses for each body part scanned outside, and repeated, were used to estimate the average effective dose of CT examinations imported into the trauma center PACS and performed at our institution [18].

Statistical Analysis

Descriptive statistics were used for patient characteristics, imported images, local imaging, and repeat rate. A Mann-Whitney U test was used for comparison of age and ISS between the patients who received and did not receive repeat CT scans. The Mann-Whitney U test was used because ISS is not a continuous variable. Pearson's χ^2 test was used to compare the gender of patients who received and did not receive repeat CT scans. P values $< .05$ were considered to represent significant differences. Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington) and SPSS version 18 (SPSS, Inc, Chicago, Illinois) were used for statistical analysis.

RESULTS

Patient Characteristics

The cohort included 500 consecutive trauma patients who were transferred from their primary hospitals, located in Washington, Idaho, Montana, Wyoming, Alaska, British Columbia, or the Yukon Territory.

Nine patients were classified as nonacute transfers (>48 hours after arrival at their initial assessing institutions) and were excluded from the study, resulting in 491

Table 1. Descriptive statistics

Variable	Value
Total trauma patients	500
Exclusions (>48 h)	9
Acute trauma transfers	491
Age (y)	40.5 ± 23.7 (0-99)
Average Injury Severity Score*	14.7 ± 10.6
Male/female	342/149

Note: Data are expressed as numbers or as mean ± SD (range).
*Excludes transfers for burns and ophthalmology trauma patients.

transfer patients. As shown in Table 1, there were 70% men and 30% women, with an average age of 40.5 years and an average ISS of 14.7 ± 10.6.

Outside Images Imported to the Trauma Center and Further Imaging

Of these 491 patients, 261 (53%) had outside radiographs, 318 (65%) had CT studies, and 383 (78%) had some form of imaging imported into the trauma center (Table 2).

Of the 491 transfer patients, local radiographic studies were performed on 331 patients (67%), local CT studies on 257 patients (52%), and radiography or CT (or both) on 383 (78%). Overall, there was a high rate of imaging in the patient cohort. Combining both outside and local studies, 374 patients (52%) underwent radiography, 376 (76%) CT, and 420 (86%) either radiography or CT (or both). Thus, only 71 patients (14%) had no imaging at all. These 71 patients were either burn or ophthalmology patients. Of the 420 patients who underwent radiography and/or CT either at the outside institution or locally, 383 (91%) had radiographs and/or CT studies imported into the trauma center's PACS. A further patient had MRI scans imported. Ninety-two of 318 patients (29%) whose outside CT studies were imported into our PACS underwent at least one further CT scan at our trauma center.

CT

As shown in Table 3, the 69 repeat local CT studies were performed on 55 patients, representing 17% of patients who had CT studies imported and 11% of all included patients. Overall, patients who underwent repeat CT scans were older and more severely injured than patients who did not undergo repeat imaging. Of the 852 CT studies imported into the PACS, 69 (8%) were repeated. Table 4 illustrates the subtypes of repeat CT studies.

Reasons for repeat CT were inadequate outside CT for 36 patients (52%), unknown for 21 patients (30%), 3-D reconstructions required for surgery for 9 patients (13%), and images inaccessible on the PACS for 3 patients (4.3%). In all cases classified as unknown, the radiology report compared the repeat CT with the outside CT study, indicating that it was viewable while the patient was in the trauma center.

Radiography

Radiographic studies imported to and performed at the trauma center are shown in Table 5. Including extremity studies, 576 radiographic studies were repeated in the trauma center ED, representing 12% of all radiographic studies and more than half of all imported radiographs.

Estimated Cost of Transferred Imaging CT Scans

We estimated the cost directly attributable to the electronic transfer of CT studies and the cost of repeat CT studies (Table 6). The total estimated cost of CT imaging transferred in 491 patients, using combined CMS technical and professional reimbursement rates, over the 45 days of our study, was $244,373.69, or $768.09 per patient who had CT studies transferred. The transferred studies with the highest aggregate value were of the head, cervical spine, abdomen, and pelvis.

On the basis of the same CMS rates, the estimated value of CT studies that were repeated at the trauma center was $20,495.95, or $84.65 per patient who had imported outside CT studies.

All transferred imaging is reanalyzed at the trauma center. This reanalysis is charged by the trauma center as a professional fee only if there is a discrepancy with the primary read, which is about 10% of the time.

Table 2. Outside and local radiographic and CT studies

Variable	n
Number of patients with outside studies	
Radiography*	261 (53%†)
CT	318 (65%†)
Radiography or CT	383 (78%†)
Number of outside studies	
Radiography†	380 (31%‡)
CT†	852 (69%‡)
Radiography and CT†	1,232 (100%‡)
Number of patients with local studies	
Radiography†	331 (67%†)
CT (% transfer patients)	257 (52%†)
Radiography or CT	383 (78%†)
Number of local studies performed	
Radiography†	699
CT	563
Number of patients with outside or local studies	
Radiography	374 (76%†)
CT	376 (76%†)
Radiography or CT	420 (86%†)

*Excludes extremity radiography.
†Percentage of total transfer patients (n = 491).
‡Percentage of outside studies imported.

Table 3. Repeat CT studies performed at Harborview Medical Center

Variable	Repeat CT	No Repeat CT	*P*[*]
Patients (% of transfer patients[*])	55 (11%)	436 (89%)	
Patients (% with outside CT[†])	55 (17%)	263 (83%)	
Total repeat CT studies (% outside CT studies)	69 (8.1%)		
Age of patients with repeat CT (y)	46.5 ± 23.1 (2-93)	39.7 ± 23.8 (0-99)	.049
Injury Severity Score	21.0 ± 10.4 (1-75)	13.9 ± 11.0 (1-75)	<.001
Male/female	38/17	304/132	.923

Note: Data are expressed as number (percentage) or as mean ± SD (range). For age and Injury Severity Score, Mann-Whitney *U* tests were used. For gender, Pearson's χ^2 test was used.
[*]Percentage of total transfer patients (n = 491).
[†]Percentage of transfer patients who had an outside CT imported into HMC (n = 381).

Average Estimated Radiation Dose Attributable to Imported and Repeat CT Studies

We used radiation dose data for CT examinations provided by Mettler et al [18] to estimate radiation dose attributable to imported and repeat studies. Of the 318 patients whose outside CT scans were imported into the trauma center PACS, on the basis of the body regions scanned, the average patient had an effective dose of 11.3 mSv attributable to the imported CT studies. Repeat CT imaging, on the basis of the body regions rescanned, accounted for an average additional 1.0 mSv per patient in these 318 patients. The average effective dose from additional completion CT studies accounted for 4.8 mSv per patient in the 491 transferred patients.

DISCUSSION

The establishment of regional trauma systems where patients are transferred from nontertiary EDs to major trauma centers has been shown to improve survival [4]. Transfer patients are often critically ill, with higher mortality rates and longer hospital stays than patients who undergo treatment at the hospital of first arrival. Imaging utilization, especially CT and radiography, on transferred trauma patients is high. In our study, 86% of patients underwent radiography or CT, and 76% had CT scans at either the outside or the local trauma center. This rate is comparable with imaging rates in other published studies [5-7,19]. A significant rise in the utilization of ED CT has been observed in the past decade, and this cannot be accounted for by a rise in the prevalence of life-threatening conditions, suggesting an increase in health care costs and radiation exposure in emergency patients [1,2,19]. Also concerning, recent studies have shown a high repeat CT rate in patients transferred to level I trauma centers. In one prospective cohort of 410 patients, 53.2% of CT scans performed at outside institutions were repeated upon transfer [6]. In a study by Sung et al [7], 29% of 425 CT scans were repeated after patient transfer. In another study examining repeat rate, 63 of 138 patients (40%) underwent repeat imaging at the receiving institution [5]. In our study, 8.1% of CT studies were repeated in 17% of patients. Thus, using a combination of the Internet and CDs to transfer images during interho-

Table 4. CT studies imported to and performed at the trauma center

Type of CT Scan	Outside CT Study Imported	Completion Trauma Center CT	Repeat Trauma Center CT
Head	232	138	5
Maxillofacial	70	32	17
Cervical spine	189	70	12
Thoracic spine	10	9	2
Lumbar spine	12	6	1
Sacral spine	2	0	0
Chest	76	12	2
Abdomen	114	58	11
Pelvis	122	69	18
Extremity	22	13	1
CT cystography	0	16	0
CTA head	0	36	0
CTA neck	2	27	0
CTA chest	0	8	0
Total	852	494	69

Note: CTA = CT angiography.

Table 5. Types of radiographic studies imported and performed at the trauma center

Type of Radiography	Outside Radiography	Completion Radiography	Repeat Radiography
Skull	5	3	
Cervical spine	48	172	75
Thoracic spine	12	116	15
Lumbar spine	21	61	19
Chest	193	313	0
Abdomen	7	4	2
Pelvis	94	156	97
Extremity	656	2,345	368
Total	1,036	3,167	576

Note: Outside radiographic studies were imported into the trauma center's PACS. Completion studies were not done at the outside facility but were done after transfer. Repeat radiographic studies were done of the same body region as a radiographic (or CT) study done outside, not indicated by a clinical protocol or change in clinical status, or after treatment. Hence, there were more repeat radiographic studies of the cervical and thoracic spine and pelvis than radiographic studies imported. No chest radiographic studies were deemed unnecessary because these are routinely performed on all patients after transfer for surveillance purposes. Where a radiographic study comprises a series of images (eg, a two-view chest study), this is counted as one radiographic study for statistical analysis.

spital transfer is associated with a lower repeat CT rate than in the literature, suggesting that regional PACS networks may be useful for reducing cost and radiation exposure associated with trauma.

There are several probable reasons why our repeat CT rate is lower than those of other institutions. First, by informing our referring hospitals of our minimal standards for CT, we have likely reduced the number of outside CT studies performed that our trauma center must repeat.

Second, our trauma center has an onsite radiologist in the ED who examines all incoming CT studies to determine acceptability, to determine whether repeat imaging is absolutely necessary, and to advise the clinical services. Hence, the radiologist functions as a gatekeeper. The higher ISS and ages of patients who underwent repeat CT suggests that radiologists and clinicians may be targeting their repeat imaging to patients who are less radiosensitive and who could benefit the most.

Third, we rarely encounter CD incompatibility issues in our daily practice. We prioritized Internet links with outside hospitals that produce CDs that could not be imported into our PACS during the implementation of our imaging network.

Fourth, the reduction in repeat imaging may be attributable to our ability to telephone the outside hospital and request the transmission of additional CT reconstructions after the patient has arrived. In our experience, the transferring hospital is almost always prepared to accommodate this request. Of note, the persistence of repeat

Table 6. Cost of transferred imaging and repeat CT studies

Type of CT	Total Estimated Cost of Imported CT Studies	Total Estimated Cost of Repeat CT Studies
Head	$55,452.64	$1,195.10
Maxillofacial	$17,765.30	$4,314.43
Cervical spine	$48,177.99	$3,058.92
Thoracic spine*	$665.72	$121.04
Lumbosacral spine*	$847.28	$60.52
Chest	$28,303.92	$744.84
Abdomen	$42,699.84	$3,371.04
Pelvis	$44,935.04	$6,629.76
Extremity	$5,525.96	$251.18
Total	$244,373.69	$20,495.95
Per patient with outside CT studies sent	$768.09	$84.65

*Technical components for the thoracic, lumbar, and sacral spine are excluded from analysis because these are usually reconstructed from the body CT images of the same region and incur no additional technical charge.

pelvic CT studies for the purpose of 3-D reconstructions remains a problem. The pelvic trauma surgeons are aware of this and have reduced the number of repeat CT studies for this indication.

There were limitations to our study. It is unclear if all studies were transferred from the outside hospitals. As a result, we may have underestimated the repeat rate. However, of patients who had either outside or local imaging, 92% had either CT studies or radiographs transferred to the trauma center. It is likely that if a single study was transferred, all studies were transferred. This suggests that few studies were repeated at the trauma center because they could not be transferred into the PACS. Our definition of repeat CT differs from those used in other studies, making direct comparison of repeat rates difficult. We deliberately excluded repeat CT of the same body region if it was performed after an intervention or as part of our follow-up imaging algorithm, whereas others have not done so [5,7]. Although evaluating each CT scan was time consuming, we believe that this technique is a more accurate means of determining whether repeat CT studies were clinically indicated or not.

We looked at our own repeat rate and compared it with those of similar academic medical centers rather than examining our repeat rate before and after the implementation of our image transfer system. This is because our electronic image transfer system was such a critical component of our clinical service at the time of our study that we could not do a meaningful comparison before and after the rollout of our Internet-based and CD-based image transfer system. Caution is recommended in comparing our repeat rate with those of other institutions that may receive transfer patients for different reasons and have different policies, protocols, and approval processes for repeat examinations.

Our estimate of cost is based on Washington State CMS reimbursement rates, not the actual cost of performing an examination. This is a technique that has been used in prior imaging cost-effectiveness studies [20-23]. Moreover, we did not factor in the cost of installing and maintaining our image transfer system into our cost-saving estimate. This is because we used software that was already licensed to our enterprise, and the system administration was absorbed into our large team of PACS and radiology information system personnel, making an accurate estimate impossible. These costs vary widely on the basis of the type of image-transfer system that an enterprise chooses to install. Also note that the standardized CT radiation dose values used to estimate radiation dose may underestimate the true radiation dose [24].

Because it was not possible to determine the rationale for additional radiographic studies in this patient cohort, it is likely we underestimated the number of repeat extremity radiographic studies performed. The most commonly repeated radiographic examinations were of the cervical spine and pelvis. This is likely the result of the common practice of ordering a "trauma series" that includes views of the cervical spine, chest, and pelvis at our trauma center.

There are important potential benefits to Internet-based image transfer not examined by this study. There are valid concerns that the overutilization of advanced imaging at community hospitals may delay transfer to a regional trauma center for definitive care [25]. Delays have been associated with worse patient outcomes [26], although the overall mortality of trauma patients undergoing transfer has not been shown to be higher than direct level I trauma center admissions [27]. If imaging studies (in the form of CDs or films) accompany the patient during transfer, there is the potential for a further delay in transfer while CDs and films are prepared and delivered to the patient. Using the Internet to send images offers the potential to overcome this delay. Images can be sent independently before, during, or after patient transfer.

Moreover, using the Internet to transfer images also permits teleconsultation with a trauma specialist, avoids unnecessary transfer, and potentially improves care for nontransferred patients as well as transferred nontrauma patients [12].

CONCLUSIONS

Our goal was to compare transferred trauma patient CT repeat rates using electronic transfer of imaging as well as an open CD importation policy with those in the literature that involve solely CD-based or hardcopy-based transfer. We show that repeat rates using electronic transfer of imaging are lower than those in the literature and that because of this, patients are exposed to less radiation and the imaging charges are lower to the health care system as a whole. Further studies to evaluate the effect of this technology on transfer time and patient morbidity and mortality are necessary to accurately determine the full impact on health care costs and outcomes.

TAKE-HOME POINTS

- Using a regional PACS network to transfer images of transferred trauma patients reduces imaging costs and radiation exposure compared with more traditional methods of image transfer.
- The vast majority of nonburn, nonophthalmology trauma patients who require transfer to a level I trauma center undergo some sort of radiographic imaging, usually radiography or CT.
- Transferred trauma patients who are reimaged are more likely to be older and more severely injured than their counterparts who do not undergo repeat imaging.

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