

Airway, breathing, computed tomographic scanning: Duplicate computed tomographic imaging after transfer to trauma center

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BACKGROUND:	Trauma patients imaged at community hospitals often receive duplicate computed tomographic (CT) imaging after transfer to regional trauma centers (RTCs). CT scanning is expensive, is resource intensive, and has acknowledged radiation risk to the patient. The objective of this study was to review and evaluate the frequency, indications, impact on patient management, as well as associated radiation and charges for duplicate CT imaging of trauma patients transferred to our RTC from outside hospitals (OSH).
METHODS:	Patients transferred to our RTC between September 2009 and August 2010 were evaluated prospectively. The OSH patients' charts and provider interviews were used to determine the reasons for repeated scans. The primary outcome was frequency of duplicate CT scan, defined as a repeated CT image of the same body part within 24 hours. The reason for duplicate imaging and impact on patient management was categorized. Radiation exposure and charges for duplicate scans were also determined.
RESULTS:	Of the 185 patients transferred to our facility, 177 were eligible. CT examinations at the OSH were performed on 137 patients (77%). A duplicate CT examination occurred in 38 patients (28%). The most common reason for duplicate CT scanning was lack of thin-section multiplanar data, on images sent via CD-ROM (37%). There was a change in management in 16 patients (42%). The patients with duplicate scanning received a median of 10.2 mSv (interquartile range, 6.6–15.7 mSv) of additional radiation, with a median charge of \$409 (interquartile range, \$307–\$734).
CONCLUSION:	More than one third of duplicated scans performed on transferred trauma patients were potentially avoidable, primary owing to inadequate transfer of data from the OSH CT scan. The capacity of a single CD-ROM is insufficient to contain full imaging data from a trauma scan, and establishing direct links to imaging data from OSHs would decrease the number of repeated CT scans performed on transferred trauma patients. (<i>J Trauma Acute Care Surg.</i> 2013;74: 813–817. Copyright © 2013 by Lippincott Williams & Wilkins)
LEVEL OF EVIDENCE:	Care management study, level III.
KEY WORDS:	Diagnostic imaging; radiation dosage; multiple trauma; transfer agreement.

Nearly 30% of Americans in rural areas live more than 30 miles away from an American College of Surgeons-verified trauma center.¹ This is particularly true for the state of Vermont, which has a large rural population. Trauma patients in more rural areas are typically assessed and stabilized at the smaller local hospitals and then, if necessary, transferred to a regional Level I trauma center.

Initial assessment of trauma patients at the smaller facilities frequently involves computed tomographic (CT) scanning. For a variety of reasons, some of which are unnecessary, these CT scans are often repeated once the patient arrives at

the Level I trauma center.² Duplicated CT scanning not only increases patient radiation and contrast exposure but also is a waste of health care dollars.

The reasons cited for repeated imaging can be broken down grossly into clinical and technical categories. Technical reasons include inability to open accompanying CD-ROM, inadequate transferred data, radiology report not included, and so on. The primary clinical reason usually involves a change in patient condition. To our knowledge, the frequency and consequences of repeated imaging, including patient radiation exposure, cost to payers, and effects on clinical management, have not been studied.

Repeated CT imaging increases radiation and contrast exposure.^{3–6} CT scanning is also resource intensive and carries with it obligatory expenses including equipment charges, technical support, and radiology consultation.^{7–9}

We sought to determine the incidence of duplicate CT scans in trauma patients who were transferred from outside hospitals (OSH) to our rural Level I trauma center. We prospectively followed patients from their arrival in our emergency department (ED) until hospital discharge and interviewed their providers. We evaluated outcomes pertinent to the repeated imaging, including the rationale for the order, whether

Submitted: August 16, 2012; Revised: January 21, 2013; Accepted: September 19, 2012.
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DOI: 10.1097/TA.0b013e3182789399

J Trauma Acute Care Surg
Volume 74, Number 3

duplicate imaging changed patient management, effective radiation dose to the patient, and associated charges for the repeated examinations.

PATIENTS AND METHODS

Study Design

We performed a prospective, observational study of trauma patients transferred to our Level I trauma center Fletcher Allen Health Care (FAHC), including an interviewer-assisted survey of the physicians caring for these trauma patients. Our institutional review board approved this study with a waiver of consent. All providers were notified and encouraged to participate in the study by their clinical leaders.

Setting and Subjects

This study was conducted at a rural, academic medical center that houses the region's only Level I trauma center (FAHC). We enrolled a convenience sample of subjects based on availability of the research team. CT images are usually sent as digital images on a CD or DVD from the OSH, although some OSH directly transfer images electronically via Picture Archiving and Communication System (PACS). All trauma patients, regardless of age, who were transferred from outlying hospitals for traumatic injuries during the period of September 2009 to August 2010 were eligible for the study (Fig. 1). Patients were excluded from the study if they were transferred for burn care and had no other trauma. All study patients were monitored to determine if they had a second CT scan ordered during the first 24 hours at our regional trauma

center (RTC). If so, the provider who ordered the duplicate CT scan was interviewed.

Data Collection and Processing

Data were collected in the ED at the time of transfer and again at hospital discharge. Patient data were obtained from medical records and interviews of the physician managing the trauma patient using standardized questions.

After patient discharge, a single researcher (H.B.M.) determined outcomes by reviewing hospital records. Data collected included imaging studies, Injury Severity Score (ISS), discharge disposition, total hospital days, and overall survival. "Duplicate CT scan" was defined as a CT scan performed at our Level I trauma center of the same body part within 24 hours of the initial scan from the OSH. "Additional CT scan" was defined as a patient receiving a different CT imaging protocol or body part. For example, for a patient with a CT scan of the head at an OSH, CT head angiography in our ED would be considered an additional study. A patient could receive multiple duplicate and additional studies. Effective radiation dose was calculated using the exposure chart developed by the American College of Radiology and the Radiology Society of North America.⁷ The charge for each duplicate scan on the first 137 patients was determined by a review of the radiology billing records and assessment of the amount each patient was billed.

RESULTS

Of the 185 trauma patients transferred to FAHC, 8 were excluded, 1 for incomplete data, 2 who had burn injuries, and

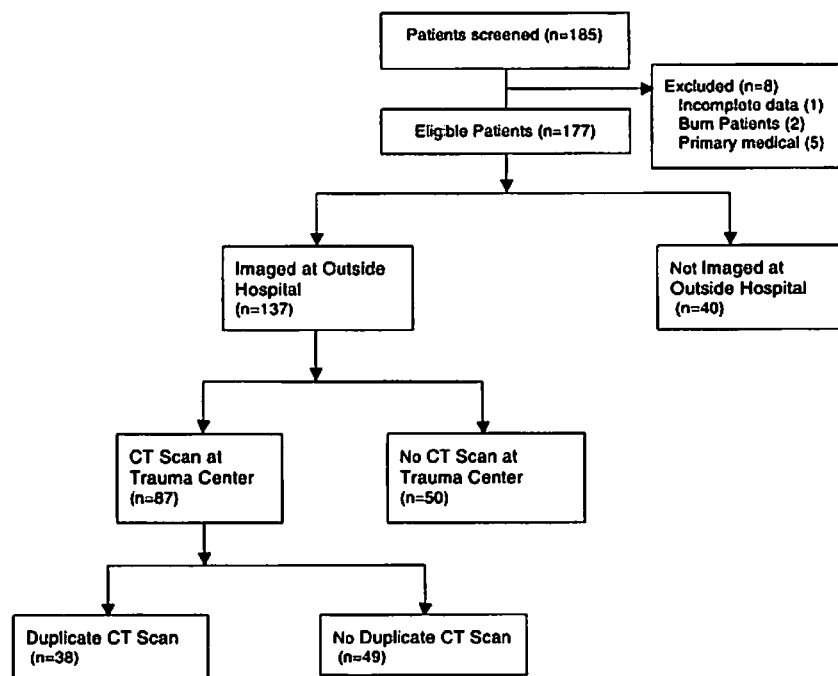


Figure 1. Study participants.

5 medical patients with no trauma. At the referring hospital, 40 did not receive a CT scan, leaving 137 who met the inclusion criteria. The median age of the patients was 44 years, with 68% male (Table 1). The most common mechanisms of injury included fall (32%), motor vehicle collision (28%), all-terrain vehicle/motorcycle collision (16%), and assault/blunt trauma (8%). Of the 137 patients who received a CT scan at the OSH, 87 (63%) also received CT scans at FAHC, with 38 patients (28%) receiving duplicate CT scans (Table 2).

The physician interview response rate regarding the indication for duplicate CT scans was 85% (39 of 46 patients). The primary reasons for duplicate CT scanning cited during the interview process with the ordering physician were inadequate transfer of data, decompensation of patient, did not agree with OSH report, other, and unknown (Fig. 2). When we reviewed the reasons for inadequate data transfer, we found that these patients arrived at the trauma center with CD-ROM containing OSH imaging data. Surprisingly, of these 14 patients, in only 2 cases, the CD-ROMs could not be opened. For 12 of 14 patients, we found that the capacity of a single CD-ROM was insufficient to contain a full trauma scan with thin section multiplanar imaging data needed for spine reconstructions. In all of these cases, OSHs had sent only the rendered images but not the raw data, to fit the images onto the CD. In contrast, images arriving from hospitals with direct digital links using PACSs were adequate.

Physicians reported a change in patient management in 16 patients (42%) who received duplicate CT scans (Table 3). The median additional radiation dose was 10.2 mSv (interquartile range [IQR], 6.6–15.7). The median additional charge was \$409 (IQR, \$307–\$734). Estimation of radiation dose and additional charge was only performed on the first 21 patients receiving duplicate CT scans.

DISCUSSION

Frequency of CT Scanning

All patients enrolled in this study had OSH CT imaging on multidetector CT scanners. The percentage of patients receiving duplicate CT scans at our trauma center (28%) was less than that reported by other studies, which ranges from 40% to 91%.^{10–13} A prospective study from Arizona showed that

TABLE 2. Frequency of diagnostic CT scans in patients transferred to trauma center from referring hospitals in region.

	Vermont	New York*	Total
CT at outside hospital	56	81	137
CT at trauma center	41 (73%)	47 (58%)	87 (49%)
Duplicate CT scan	17 (30%)	21 (26%)	38 (28%)
Total CTs/patient, median (IQR)	2 (1–3)	1 (1–3)	2 (1–3)

IQR, interquartile range

*Includes one patient from Hampshire.

transferred trauma patients who received duplicate CT scans spent more time at an OSH and had a higher ISS;¹² however, reasons for these scans and the impact on patient management were not described. Our results are consistent with other reports showing that duplicate CT scanning is most heavily used in the assessment of central nervous system injuries in trauma patients.¹⁰ While our study is not the first to describe the frequency of duplicate CT imaging, our data support the claim that, despite variability in the frequency of this practice, it is widespread in trauma centers across the country.

Reasons for Duplicate Scanning

Our study is the first to prospectively assess the reasons for duplicate imaging in transferred trauma patients. “Inadequate transfer of data” was the most commonly cited indication for requesting duplicate CT examinations in our study. Surprisingly, the duplicate scans were most frequently ordered because thin section multiplanar data were not included in the transferred CT study. At the time of data collection, 50% of the OSH in this study had direct PACS-to-PACS transfer capabilities, which was only intermittently used. The alternative means of sending data was to provide a CD or DVD with the patient, which was then uploaded into our PACS system. One of the underlying factors for the inadequate transfer of data is the small storage capacity of a CD (0.7 gigabytes). In most cases, CD storage is adequate for only one body part. Therefore, using a CD for trauma patients, who have multiple examinations with inherently thin data sets, is the primary cause of “inadequate data.” A DVD’s storage capacity (5 gigabytes) may mitigate this problem but is not the ultimate solution.

TABLE 1. Demographics of Study Population

Patients	Total (n = 177)
Male, n (%)	120 (68)
Age, median	44.1
Pediatric, <18 y, n (%)	25 (14)
ISS, median	14
Mechanism of injury, n (%)	
Fall	57 (32)
Motor vehicle collision	49 (28)
All-terrain vehicle/motorcycle collision	28 (16)
Assault/blunt trauma	14 (8)
Sports injury	10 (6)
Penetrating trauma	9 (5)
Other	10 (6)

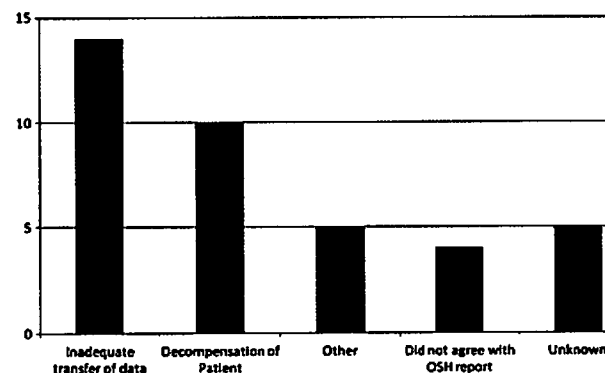


Figure 2. Reasons for duplicate CT scanning.

TABLE 3. Duplicate CT Scans: Impact on Management, Radiation Exposure, and Charges

	Patients Receiving Duplicate CT scans (n = 38)
Change in patient management, n (%)	16 (42%)
Radiation dose for duplicate studies, median (IQR), mSv	10.2 (6.6–15.7)*
Billing charges, median (IQR)	\$1,901 (\$1,901–\$3,800)*

*Data are for first 21 patients with duplicate scans.

The study by Gupta et al.¹⁰ reported that the predominant reason for repeating a head CT scan was progression of symptoms. In our study, decompensation of the patient or progression of symptoms was given a minority of the time as the reason for duplicate CT scanning (10 of 38 patients, 26%), suggesting that there is variability among institutions for the rationale of duplicate scanning. Both our study and the study of Cook et al.¹⁴ support the conclusion that duplicate CT scanning is not commonly related to patient decompensation. The study of Cook et al. found that duplicate CT scans did not find new injuries but that review of initial OSH scans by the trauma center radiologist did identify injuries that were not originally identified by the OSH.¹⁴ Previous studies assessing the impact of follow-up imaging of injured patients suggest that this practice rarely alters the patient's care.^{7–9,15–18} Sung et al.¹⁹ published a retrospective article on duplicate imaging in 2009, including all transferred patients undergoing repeated imaging whose films were reviewed by an in-house radiologist. The data showed that 35% of all repeated scans could be avoided, and the incidence of avoidable CT scanning for trauma patients was nearly three times that of nontrauma patients.

Effective Radiation Dose

The median effective radiation dose from the initial 21 duplicate scans was 10.2 mSv (Table 3). However, at least 3 (14%) of 21 patients with duplicate scans received greater than 30 mSv of additional radiation. Smith-Bindman et al.²⁰ reported that there can be a 13-fold variability in radiation from CT studies of the same body part from different institutions owing to lack of standardization of imaging techniques. Our effective radiation doses were calculated from a standardized chart based on radiation exposure at our RTC, where we use dose reduction technology. We were unable to verify if the referring OSHs in our study use the same scanning protocols, so actual radiation doses that patients are receiving from OSHs may have been underestimated. This study's finding that up to 37% of duplicate studies could have been avoided with adequate data transfer, supports sending CT images via a direct PACS-to-PACS transfer, which provides all of the necessary data for image reconstruction, as a means to decrease rates of duplicate scanning in transferred trauma patients.

Limitations

This study has several limitations. Our patient population was a convenience sample because we were unable to continually enroll patients because our research team was not available during holidays and semester break. We cannot be

certain that the patient population we studied completely reflects the incidence of these types of scans. However, we did enroll patients on nights and weekends and do not have any reason to suspect selection bias, and furthermore, we have demonstrated in a prospective fashion that duplicate scanning is present at our institution to a similar, although smaller, extent than 2 previous retrospective studies. We may be underreporting the true duplicate CT incidence because of our convenience sample. Before enrollment of patients for this study, we ran a 3-month pilot study to refine patient enrollment and data collection (March to May 2009). This preliminary data (not included in this article) had a similar incidence of duplicate scanning. Another limitation is that we lacked 100% participation in survey completion by physicians ordering duplicate scans. Owing to the nature of the ED during trauma activations, our researchers in some cases were unable to interview the physician ordering the scan. It is possible that some physicians felt uncomfortable answering the questionnaire and there may be potential bias in their choice of answers that we are unable to eliminate. Because our primary outcome was a robust determination of the incidence of duplicate scans, we present the secondary outcomes in descriptive fashion without an attempt to perform inferential statistics or make overreaching generalizations.

CONCLUSION

Duplicate CT imaging of the same body part occurred in 28% of patients initially imaged at OSH. The most common reason (37%) for duplicated CT scanning at FAHC was inadequate transferred data from the OSH CT scan. Most commonly, thin section data were not always included with the transferred images. These duplicate CT scans might have been avoided if all of the CT data had been transferred to the RTC using PACS technology rather than CD-ROM. Strategies should be introduced to minimize duplicate CT scans to improve patient care, reduce radiation exposure, and decrease hospital charges for trauma patients transferred from referring hospitals to our Level I trauma center hospital.

AUTHORSHIP

H.B.M., K.K.D., G.M.E., B.A.C., S.M.L., M.F.O., and K.F. designed this study. H.B.M., M.F.O., and K.F. reviewed the literature. H.B.M., S.B.L., T.M.-G., L.D., M.H.S., M.F.O., and K.F. collected the data, which all authors participated in analyzing and interpreting. H.B.M., S.B.L., G.M.E., B.A.C., S.M.L., M.F.O., and K.F. contributed to writing and critically revising the manuscript.

DISCLOSURE

The authors declare no conflicts of interest.

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