Journal of Acute Medicine 10(3): 106-114, 2020
DOI:10.6705/j.jacme.202009_10(3).0002
Original Article

Frequency, Recognition, and Potential Risk Factors of Incidental Findings on Trauma Computed Tomography Scans: A Cross-Sectional Study at an Urban Level One Trauma Center

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Background: Computed tomography (CT) use in injured patients has continuously increased in the past decades. We designed and undertook this study to evaluate the frequency, and potential risks of incidental findings (IFs), and how they were processed in trauma patients receiving CT scans.
Methods: We retrospectively reviewed CT scans, official CT reports, and basic demographics in trauma patients who received CT scans at our emergency department in 2016. Scans with IFs prompted a detailed review of medical records to determine clinical significance and how they were processed. IFs were classified into three categories: category I (potentially severe condition, in-time management required), category II (not urgent, follow-up needed), and category III (of minor concern). Multivariable logistic regression models were fitted to determine patient characteristics associated with IFs.
Results: In the 4,092 scans enrolled, IFs were identified in 649 (15.9%). There were 13 (2.0%) category I, 306 (47.2%) category II, and 330 (50.8%) category III IFs. Patients with IFs were older than those without. No sex-based difference was found. Most (61.5%) of the scans were performed for the head; however, the abdomen had the highest IF prevalence (26.2%). Documentation about IFs was poor; 31% of category I, 91.9% of category II, and 97.0% of category III have no related record. Old age remains the risk predicting the presence of IFs, and every year of increasing age was independently associated with a higher prevalence of IFs (OR: 1.019; 95% CI: 1.015–1.024).
Conclusions: IFs are common in trauma CT scans; however, recognition and management remain poor. Abdomen and chest scans, and CT in older patients should remind us of increasing risks of IFs.

Key words: *injuries, computed tomography, incidental findings, malpractice, patient safety*

Introduction

Computed tomography (CT) use in injured patients has continuously increased in the past two decades. Possible explanations for the increased use of advanced radiography include increasing accessibility, greater sensitivity to detect injury, physician-related factors, expectations of patients and families,[1] and for some physicians, fear of malpractice litigation due to a missed diagnosis.[2] The widespread use of CT has increased exposure to ionizing radiation, medical expenditure, and has prolonged the stay in the emergency department (ED); however, no corresponding improvement in diagnosis, length of hospitalization, or mortality has been demonstrated.[3,4]

Received: August 26, 2019; Revised: December 5, 2019 (2nd); Accepted: January 17, 2020.
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With the increasing resolution of high-definition spiral CT scanning, numerous non-injury related lesions are revealed in a significant percentage of patients.[5-10] These incidental findings (IFs) vary in their importance, from trivial lesions without clinical significance to lesions that may greatly impact the health of the trauma patient.[7-9] Documentation of IFs and suggestions or referrals provided to patients are essential both medically and legally to prove that qualified medical services and patient notification have been completed. However, previous studies have shown that many IFs or any related specialty physician referrals were not documented.[6,11,12] This discrepancy leaves the patient at risk for delayed diagnosis and treatment and exposes emergency physicians and trauma surgeons to threats of malpractice litigation for missed diagnosis. Worryingly, though undocumented IFs are a serious issue that may jeopardize the safety of patients, medical providers, and the hospital, only a limited number of studies described efforts to mitigate the risks.[7,13,14]

Methods

Patient Selection and Data Collection

To evaluate the frequency and clinical importance of incidental CT findings in trauma patients, we conducted this cross-sectional, retrospective study at an urban Level I trauma center with an annual census of 100,000 ED visits. In study ED, CT on indications rather than a whole-body CT policy is adopted and encouraged. First, we identified trauma patients who received CT scans during the indexed ED visit from January 1 to December 31 in 2016 through the electronic health record (EHR). Contents of EHR, CT images, official reports from certified radiologists of these patients, and trauma registries of hospitalized patients maintained by the trauma manager, were thereafter reviewed. Only the patients who received CT scans for trauma evaluation were enrolled. Duplicated scans (e.g., follow-up CT scanning of the brain) during the indexed ED visit were excluded because new IFs seldom happen in such a short time interval. Cases and scans with incomplete information needed for analysis were also excluded. This study was approved by the hospital ethics committee.

IF Category

According to previous studies, the IFs were defined as CT findings not related to trauma but are potentially dangerous to the patient's present or future health.[5-11] Comparable to previous studies, IFs were classified into three categories:[5,7,11] category I (e.g., cancer) is potentially serious conditions that need in-time diagnostic work-ups, consultation of other specialties, and active managements; category II (e.g., gallbladder stones) is non-emergent, with diagnostic work-ups and managements dependent on patients' symptoms; category III (e.g., renal cyst) is findings of minor concern, with no diagnostic work-up required. According to previous studies, the following IFs were excluded because of clinical irrelevance: degenerative joint diseases, atherosclerotic vessel disease, age-related brain atrophy, signs of earlier operations, and findings are already known from previous imaging examinations.[5,7,8]

Training and Category Adjudication

Before study initiation, a detailed chart review methodology was designed and three emergency physicians were invited to join as the reviewer. They were trained by reading relevant literatures, and reviewing EHR of sampled trauma patients as the pilot study. Discussion of conflict between reviewers was undertaken to obtain a consensus of IFs and their category. After the pilot study, the chart reviewers agreed upon a list of exampled IFs which was classified into the three categories. The working table of examples was then used as a reference all through the process of categorization. During the study, two reviewers reviewed the EHR, images, and radiological reports first. The category card was raised simultaneously when they had a decision. If there was any disagreement, the third reviewer was invited to participate and the consensus was achieved by the Stepladder technique.

IF Management

Based on the clinical significance and emergency of IFs, additional workups and managements could have been completed during the initial ED encounter, indexed hospitalization, or referral visit. Therefore, for patients with IFs, we checked documentation about the IFs, suggestions, consultations, or referrals made during the initial ED visit, in-patient stays, and subsequent clinic visits.

Statistical Analysis

Descriptive statistics and SPSS software (IBM

SPSS Statistics for Windows, Version 19.0; IBM Corp., Armonk, NY, USA) were used to describe and analyze the data. To identify the clinical factor associated with IFs, the Student's t-test for continuous variables and chi-square tests for categorical variables usually showed a univariate analysis. The variables we collected included age, sex, body parts of CT, and disposition after ED management. A p value of < 0.05 was considered statistically significant, and all statistical tests were two-tailed. For multivariate analysis, the variables with a statistical significance in the univariate analysis were selected into a logistic regression analysis to calculate the adjusted odds ratio (aOR). Although sex is not statistically significant in univariate analysis, we also put it into the regression model for adjustment. Results were presented as mean ± standard deviation or median with interquartile ranges, p values, and aOR with 95% confidence interval (CI).

Results

In 2016, there were 15,978 visits for traumatic injuries, and 4,173 CT scans were performed. After excluding 20 duplicate scans and 61 scans without complete records, 4,092 scans were enrolled in this study. Among these, 1,827 (44.6%) scans were of female patients. We stratified scans into five groups based on anatomical location (Table 1). The head was the most commonly scanned body part (61.5%); most of these scans were used to detect intracranial injuries. Scans of the neck, chest, and abdomen constituted 9.0%, 11.5%, and 11.4% of scans, while scans of extremities constituted only 6.6% of scans.

There were 649 scans with IFs identified in 616 patients; 16 men and 9 women had IFs on scans in two locations, 3 men and 1 woman in three locations. Abdomen (26.2%) was the location with the highest incidence of IFs, followed by chest (20.2%), head (15.3%), neck (10.5%), and extremity (2.6%). In scans with IFs, 13 (2.0%) scans were classified as category I, 306 (47.2%) as category II, and 330 (50.8%) as category III (Table 2). Although category III IFs were often of no clinical concern, this was not the case with category I & II IFs, with some of the category I IFs being more serious than the traumatic injury which necessitated the index ED visit (Table 3). However, documentation of recognition and management of these IFs was very poor. In scans revealing category I IFs, 4/13 (31%) had no record of consultation, advice, or even recognition. These rates were even higher in scans that revealed category II & III IFs; 91.9% of scans with category II IFs and 97.0% of scans with category III IFs were not documented. In 616 trauma patients with IFs, 116 (18.8 %) were hospitalized, 20 (3.2 %) were transferred to another hospital, 26 (4.2 %) left against medical advice, and 454 (73.7 %) were discharged after ED management.

Regarding risk analysis, age was identified as

Table 1. Groups of trauma CT scans in 2016

Group	Number (%)
Head	2,517 (61.5)
Brain	1,730
Brain + Face	478
Brain + Orbits	147
Posterior fossa	108
Face	23
Orbits	12
Cranial CT angiography	10
Temporal bone	4
Miscellaneous	5
Neck	370 (9.0)
Neck	9
Carotid CT angiography	2
Cervical spine	359
Chest	470 (11.5)
Chest	453
Thoracic spine	17
Abdomen	466 (11.4)
Abdomen	380
Pelvis	27
Pelvis CT angiography	1
Lumbar spine	58
Extremity	269 (6.6)
Shoulders	21
Elbows	46
Wrists	31
Hands	1
Hips	32
Knees	58
Ankles	68
Legs/feet	3
CT angiography	9

CT: computed tomography.

Table 2. Number and percentage of incidental findings, per category and location

Anatomic group	Incidental findings			Sum	IF incidence[a] [%]
	Category I	Category II	Category III		
Head	2 (A[b]: 0.5; C[c]: 15.4)	132 (A: 34.2; C: 43.1)	252 (A: 65.3; C: 76.4)	386 (59.5)[d]	386/2,517 [15.3]
Neck	2 (A: 5.1; C: 15.4)	25 (A: 64.1; C: 8.2)	12 (A: 30.8; C: 3.6)	39 (6.0)[d]	39/370 [10.5]
Chest	3 (A: 3.2; C: 23.1)	69 (A: 72.6; C: 22.5)	23 (A: 24.2; C: 7.0)	95 (14.6)[d]	95/470 [20.2]
Abdomen	6 (A: 4.9; C: 46.2)	76 (A: 62.3; C: 24.8)	40 (A: 32.8; C: 12.1)	122 (18.8)[d]	122/466 [26.2]
Extremity	0 (A: 0.0; C: 0.0)	4 (A: 57.1; C: 1.3)	3 (A: 42.9; C: 0.9)	7 (1.1)[d]	7/269 [2.6]
Sum	13 (2.0)[d]	306 (47.2)[d]	330 (50.8)[d]	649 (100)	649/4,092 [15.9]

[a]Incidence of incident findings (IFs).
[b]The “A” means percentage in the corresponding anatomic group.
[c]The “C” means percentage in the corresponding category.
[d]Percentage in total incidental findings.

an independent risk factor of IFs, not only in age groups (Fig. 1) but also for every year increase of age (for the increase of age by each year, aOR: 1.019; 95% CI: 1.015–1.024). Relative to the head, the abdomen, followed by the chest, had higher risks of IFs (Abdomen: aOR: 3.055, 95% CI: 2.370–3.939; Chest: aOR: 1.811, 95% CI: 1.392–2.355). Sex was not identified as a risk factor for IFs (aOR: 1.186, 95% CI 0.991–1.418; $p = 0.667$) (Table 4). When only clinically significant categories I & II IFs were included for analysis, the age risk increased more (for every year increase of age, aOR: 1.035; 95% CI: 1.028–1.041). Abdomen, followed by chest, and neck had higher risks of IFs (Abdomen: aOR: 6.930, 95% CI: 4.972–9.659; Chest: aOR: 4.418, 95% CI: 3.182–6.132; Neck: aOR: 2.109, 95% CI: 1.344–3.308). Sex remained not a risk factor for IFs (aOR: 1.274, 95% CI: 0.993–1.635; $p = 0.597$) (Table 5).

Discussion

In our study, a substantial percentage of IFs was found on CT scans conducted for trauma evaluation. Without appropriate referral or consultation, patient health may be compromised due to delayed diagnosis and treatment. It is also difficult to defend medical services against litigations regarding IFs if no corresponding record exists. In our cohort, 31% of category I and over 90% of category II & III had no corresponding records; 73.7% of patients with clinically significant category I & II IFs were discharged after ED management while the official radiological reports were often not yet available.

Scans involving the abdomen, followed by the chest, and the neck had the highest incidence of IFs which may be attributed to their large volumes and abundance of viscera.[8,12] Females were reported to have a higher prevalence of IFs on CT scans which may be accounted for by breast and gynecologic pathologies.[5,9] However, in our cohort, no significant sex-based difference in IFs was identified. This may be because of regional variation of diseases; specifically, only one case of breast nodules and another of uterus tumors were noted in our series. Similar to previous studies, older age was an independent risk factor of increased prevalence of IFs,[5,9,12] not only in age groups but also in every year increase of age. This was expected because the increasing prevalence of various pathologies, especially degenerative and neoplastic diseases, from senescence has been well known.[15,16] The association of age with IFs is worth noting because most developed countries comprise an aging population.

Besides the traumatic injury, doctors should not close cases before IFs are addressed. In addition to the formal radiological education during resident training,

Table 3. Category I IF in this study

Sex	Age	Mechanism of trauma	Traumatic injuries	Incidental CT findings	ISS	Disposition	Record/Mx[a]
M	76	Punch and kick	Blunt head, abdomen trauma	Hepatoma	2	Discharge from the ED	Yes/1
F	47	MVA 3 days ago	Blunt head injury	Expansive lytic lesions in C-spine	3	Discharge from the ED	Yes/1
M	44	Falling down stairs	Right clavicle fracture	Miliary lung nodules, suspected tuberculosis	6	Discharge from the ED	No/0
M	78	Fall, 2-m height	Face/chest contusion, L2 compression fracture	Obstructive, ureterovesical junction stone	9	Discharge from the ED	No/0
M	79	Falling down stairs	Head injury, limbs abrasions	Ruptured appendicitis with abscess	16	Surgery for appendicitis	Yes/2,4
F	79	Fall in the bathroom	Blunt back/buttock injuries	Lung cancer with pleura & spine metastases	3	Surgery for spine metastases	Yes/2,4
M	65	Fall, 2-m height	Blunt head/abdomen trauma, right elbow contusion	Abdominal aorta aneurysm, infrarenal, # 6 cm	6	EVAR for AAA	Yes/2,4
M	79	Knife stabbing, self-harm	Chest penetrating injury with hemothorax	Hepatoma with daughter nodules	17	Medical ward admission died 3 months later at a hospice	No/3
F	64	Pedestrian hit by a car	Head injury, facial laceration	Submandibular gland cancer	6	Discharge from the ED	Yes/2
M	75	Ground level fall	Face/left humerus fracture	Brain tumor	6	ORIF	No/2,3
M	89	Fall when pulling a drawer	Head injury, facial laceration, buttock contusion	Brain tumor	3	Discharge from the ED	No/0
M	80	Fall from the bed	Facial laceration	Pancreas tumor	3	Discharge against medical advice	No/0
F	83	MVA, hit on a pole	Legs contusion	Lung cancer, right upper lobe	6	Discharge from the ED	Yes/1

[a]Documentation and management on the IF; 0: no management; 1: referral; 2: on site consultation; 3: hospitalization; 4: surgery & hospitalization.
AAA: abdominal aortic aneurysm; CT: computed tomography; ED: emergency department; EVAR: endovascular aneurysm repair; F: female; IF: incidental finding; ISS: injury severity score; M: male; MVA: motor vehicle accident; ORIF: open reduction and internal fixation.

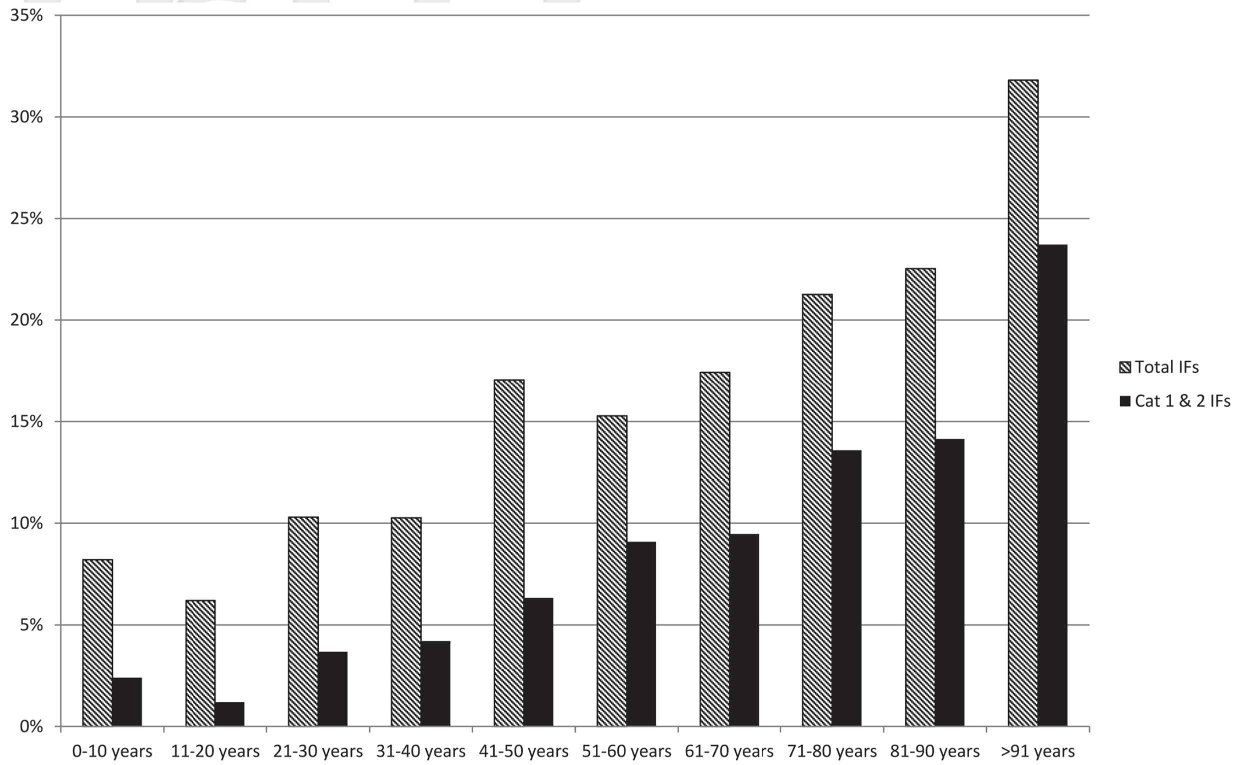

Fig. 1. Incidental findings (IFs) per age groups. Clinically significant category I & II (Cat 1 & 2) IFs were presented besides the total IFs.

Table 4. Results of risk analysis for all categories of IFs in CT scans for trauma evaluation

Variable	Scans without IFs (N = 3,443)	Scans with IFs (N = 649)	*p* value	OR	95% CI	aOR	95% CI
Sex			0.667				
Male	1,897 (55.1)[a]	364 (56.1)		1.000	Reference	1.000	Reference
Female	1,546 (44.9)	285 (43.9)		1.041	0.879–1.232	1.186	0.991–1.418
Age	52.01 ± 23.77	61.46 ± 21.31	< 0.001	1.018	1.014–1.022	1.019	1.015–1.024
Disposition			< 0.001				
Discharge	1,861 (54.1)	487 (75.0)		1.000	Reference	1.000	Reference
Hospitalization	1,402 (40.8)	116 (17.9)		0.316	0.255–0.392	0.289	0.230–0.362
DAMA	103 (3.0)	26 (4.0)		0.965	0.620–1.500	0.767	0.484–1.215
Transfer	67 (1.9)	20 (3.1)		1.141	0.685–1.898	1.079	0.638–1.825
Expire	4 (0.1)	0 (0.0)		0	0	0	0
Location of scans			< 0.001				
Head	2,131 (61.9)	386 (59.5)		1.000	Reference	1.000	Reference
Neck	331 (9.6)	39 (6.0)		0.650	0.459–0.992	0.934	0.650–1.342
Chest	376 (10.9)	95 (14.6)		1.395	1.087–1.791	1.811	1.392–2.355
Abdomen	343 (10.0)	122 (18.8)		1.964	1.555–2.480	3.055	2.370–3.939
Extremities	262 (7.6)	7 (1.1)		0.148	0.069–0.315	0.232	0.108–0.499

[a]The data present number (%).
aOR: adjusted odds ratio; CI: confidence interval; CT: computed tomography; DAMA: discharge against the medical advice; IFs: incidental findings.

Table 5. Results of risk analysis for clinically significant C1 & 2 IFs in CT scans for trauma evaluation

Variable	Scans without IFs (N = 3,443)	Scans with IFs (N = 319)	*p* value	OR	95% CI	aOR	95% CI
Sex			0.597				
Female	1,546 (44.9)[a]	138 (43.3)		1.000	Reference	1.000	Reference
Male	1,897 (55.1)	181 (56.7)		1.069	0.848–1.347	1.274	0.993–1.635
Age	52.01 ± 23.77	65.81 ± 19.36	< 0.001	1.029	1.023–1.035	1.035	1.028–1.041
Disposition			< 0.001				
Discharge	1,861 (54.1)	235 (73.7)		1.000	Reference	1.000	Reference
Hospitalization	1,402 (40.8)	65 (20.4)		0.367	0.277–0.487	0.268	0.198–0.364
DAMA	103 (3.0)	13 (4.1)		1.000	0.553–1.808	0.606	0.319–1.150
Transfer	67 (1.9)	6 (1.9)		0.709	0.304–1.653	0.605	0.251–1.459
Expire	4 (0.1)	0 (0.0)		0	0	0	0
Location of scans			< 0.001				
Head	2,131 (61.9)	134 (42.0)		1.000	Reference	1.000	Reference
Neck	331 (9.6)	27 (8.5)		1.297	0.844–1.993	2.109	1.344–3.308
Chest	376 (10.9)	72 (22.6)		3.045	2.241–4.138	4.418	3.182–6.132
Abdomen	343 (10.0)	82 (25.7)		3.802	2.824–5.119	6.930	4.972–9.659
Extremities	262 (7.6)	4 (1.3)		0.243	0.089–0.662	0.433	0.157–1.195

[a]The data present number (%).
aOR: adjusted odds ratio; C: category; CI: confidence interval; CT: computed tomography; DAMA: discharge against the medical advice; IFs: incidental findings.

continuing education of image interpretation could be helpful to improve doctors' image interpretation abilities and facilitate accurate diagnoses. However, it is usually not enough because emergency physicians and trauma surgeons usually work in noisy, chaotic, and high-pressure environments. Their cognition can be compromised by high stress.[17] More safe-guarding strategies are necessary to protect patients and healthcare providers.

Interpretations and reports from radiologists help facilitate proper diagnosis and treatment. However, radiologists often do not provide round-the-clock services that make reporting before the patient leaves the ED difficult. Furthermore, a shortage of radiologists in some hospitals makes in-time reporting impossible. Teleradiology communicates images and radiologic interpretations between any locations on the earth, thereby facilitating in-time image interpretation or diagnosis in rural healthcare facilities by radiologists with excellent subspecialty expertise.[18] The paucity of domestic radiological services at night or during holidays, that was made up for by radiological services in other countries or locations in different time zones has been reported.[19] Besides traditional solutions, artificial intelligence (AI) in imaging analysis is a promising area of healthcare innovation in recent years. AI methods could assess abundant medical images more efficiently and detect various abnormalities to provide quantitative, in addition to qualitative, radiographic assessments.[20]

Failure or delay in diagnosis can result in substantial loss of time and increased medical expenses, and has been reported as the most common medical misadventure resulting in malpractice suits.[21] Documenting patient notification and referrals based on IFs' significance and emergency are essential because it proves that standards of care have been met. Therefore, documentation could help doctors defend themselves against malpractice claims. Worryingly, documentation about IFs in our cohort was poor as in previous reports. Re-engineering of our safety system is necessary to reduce IFs' risks on patients and medical providers. There has been an outreach call system for potential missed laboratory or imaging examinations in many hospitals. Before this study, the notification system of IFs at the study hospital was as follows: the radiological department would send a text message to the doctor who prescribed the examination if the reporting radiologist thinks there is a potentially missed abnormality. After notification, the attending doctor was supposed to review this patient and provide necessary intervention. However, since there was no organized assistance and surveillance, poor documentation and intervention about the IFs were therefore not surprising. In response to this matter, we reorganized our system to dual-contact notifications, informing both the attending physician and the on-duty physician assistant leader. Then, the doctor or the physician assistant calls the patient to tell him/her about IFs. Medical advice and referrals if indicated are provided. All of the procedures are thereafter recorded on the medical record following a predetermined checklist. Many people do not know that the in-time interpretation of images in the ED by an emergency physician or trauma surgeon is only a preliminary survey. Official reports will only be available later by a radiologist. To reduce unnecessary misunderstanding, education before discharge and to the public are as important as every effort to promote correct and complete diagnosis during the ED visit.

IFs in radiological images taken for trauma evaluation are inevitable. Furthermore, increasing incidence of IFs is a fact because of an aging population and continued advances in imaging technology. Although IFs disclosed in CT scans may be irrelevant to the traumatic injury, ignorance of or delays in diagnoses of them may be harmful. Therefore, in addition to traumatic injuries, we need to notice potential IFs, especially in the abdomen, chest, and neck of elders. Besides every effort to enhance in-time correct and complete diagnosis, an easy, affordable alarm system with organized assistance and surveillance is important to catch any miss. Lastly, public education about the tentative interpretation by first-line doctors and frequent delays of official radiological reports should be promoted to avoid unnecessary misunderstanding.

Conflicts of Interest Statement

None declared.

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