Non-traumatic incidental findings in patients undergoing whole-body computed tomography at initial emergency admission

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ABSTRACT

Objective To evaluate the number, localisation and importance of non-traumatic incidental findings (IFs) in patients with suspected or obvious multiple trauma undergoing whole-body CT (WBCT) in a level-1 trauma centre.

Methods Between January 2009 and December 2013, a total of 2440 patients with trauma undergoing WBCT at admission to a level-1 trauma centre of a university hospital were retrospectively analysed, through imaging IFs unrelated to trauma with the radiological reports. All IFs were grouped into four categories according to their clinical relevance. Category 1: urgent treatment or further clarification needed; category 2: further examination and follow-up within 3–6 months required; category 3: findings with no immediate consequences for the treatment of the patient but of potential relevance in the future; category 4: harmless findings.

Results Altogether, 5440 IFs in 2440 patients (1735 male, 705 female; mean age 45.1 years) were documented. In 204 patients (8.4%) urgent category 1 findings were reported, 766 patients (31.4%) had category 2 findings, 1236 patients (50.7%) had category 3 findings and 1173 patients (48.1%) had category 4 findings. Most IFs were detected in the abdomen/pelvis (42.5%). 602 (24.7%) of the patients had no IFs.

Conclusions WBCT scans of unrelated trauma patients demonstrate a high rate of IF. A substantial percentage (8.4%) of patients had urgent category 1IFs and a high percentage (31.4%) had category 2 IFs requiring a follow-up. This high number of patients with polytrauma undergoing WBCT, having IFs of high relevance, poses a major challenge for the level-1 trauma centre in the acute and postacute management of these patients.

Key messages

What is already known on this subject?

- The use of whole-body CT (WBCT) has increased significantly over the last two decades in the management of patients with suspected multiple trauma.
- WBCT has a high sensitivity and specificity for the detection of traumatic lesions, but at the same time is likely to reveal incidental findings (IFs) unrelated to trauma.
- The relative distribution of IFs in the body has not been investigated, and the importance and the relation to age and sex of incidental CT findings deserves further evaluation.

What might this study add?

- In this retrospective analysis, approximately 75% of the patients with polytrauma undergoing WBCT had IFs, of which 8.4% required urgent treatment or work-up. Overall, there were 5440 IFs in 2440 patients, and number and severity of incidental CT findings increased with age.
- Approximately 81% of the urgent category 1 IFs were in the abdomen/pelvis and thorax. Of all IFs, approximately 43% were located in the abdomen/pelvis. Following up and communicating these findings with other departments or the primary care physician is a major challenge for level-1 trauma centres using WBCT. This aspect has to be considered in the overall organisational set-up of trauma centres.

INTRODUCTION

Multiple trauma is defined as trauma with an Injury Severity Score (ISS) of ≥16, which represents a combination of injuries causing a life-threatening condition.[1] Multiple trauma is the sixth most common cause of death worldwide.[2] In a European country like Germany with approximately 81 million inhabitants (2014), about 38 000 patients sustain multiple trauma each year.[3] A considerable proportion of these patients are male (approximately 68%–72%) and aged between 15 and 45 years.[3 4]

Due to its high diagnostic yield and wide availability, the use of CT has increased massively over the last two decades and has become a standard imaging modality in the management of patients with suspected multiple trauma.[5–9] The advent of spiral CT and multislice scanning techniques has significantly reduced radiation exposure and scan time allowing the acquisition of whole-body CT (WBCT) within seconds.[10] WBCT has a high sensitivity and specificity for the detection of trauma lesions, but at the same time is highly likely to reveal incidental findings (IFs) unrelated to trauma.[11] These IFs may be harmless anatomic variants, benign changes or normal age-related degenerative changes. However, WBCT may also reveal severe (eg, malignant) findings that need urgent treatment, further evaluation or a later follow-up. Thus, IFs place an additional

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burden on the trauma unit which is primarily responsible for the acute care of the patient.

The aim of the study was to assess the prevalence of incidental CT findings in different body regions in a large patient population undergoing WBCT in the course of trauma room management. Published studies[12] have investigated the prevalence of IFs in patients with trauma either undergoing CT scans of individual anatomical regions,[13 14] undergoing a WBCT[11 15–18] or a mix of both.[19] However, the relative body distribution of the IFs has not been published till date. At the same time, we have introduced a more stratified system of categorization of IFs, which may better reflect the actual medical requirements.

MATERIALS AND METHODS

Patients, scanning techniques and data collection

This retrospective single-centre study was conducted in a level-1 trauma centre of a German university hospital. Patients with suspected or obvious multiple trauma who were admitted to the trauma room from 1 January 2009 to 31 December 2013 and who underwent WBCT on admission were included. Patients undergoing CT imaging of a certain body region only, patients who were unconscious with unknown cause and patients who were initially admitted to a different hospital and later transferred to the level-1 centre were excluded from the study.

Two different CT scanners were used to perform WBCT scans: a 16-slice CT scanner (light speed; General Electric, Fairfield, Connecticut, USA) and a 64-slice CT scanner (light speed VCT; General Electric). The WBCT protocol included an unenhanced scan of the head, followed by a contrast-enhanced scan of the neck, thorax, abdomen and pelvis with a scan range from the skull base to approximately 5 cm below the symphysis. The contrast-enhanced scan was performed using the split bolus technique, with a first bolus of 100 mL contrast medium (Ultravist 370; Bayer Healthcare, Berlin, Germany at 2 mL/s) and 20 mL saline (1 mL/s), immediately followed by a second bolus of 60 mL contrast medium (4 mL/s) and 40 mL saline (4 mL/s); scan delay was 85 s after initial contrast medium injection. The acquired axial images and the routinely generated sagittal and coronal reconstructions were stored in and accessed with the picture archiving and communication system (GE Centricity 4.1; General Electric Healthcare, Buckinghamshire, UK) and the radiology information system (RIS).

The written radiologist interpretations of the WBCT examinations were reviewed for documented IFs, that is, findings unrelated to the trauma. Excluded were findings which may have triggered the trauma, for example, a ruptured cerebral aneurysm with subarachnoid haemorrhage and consecutive loss of consciousness causing an injury. If the nature of a finding (incidental vs non-incidental) was not obvious, patient files were reviewed regarding diagnoses, diagnosis-related group coding and trauma mechanism. Trauma mechanism, age and sex of the patients were recorded.

IFs were documented in five body regions: head, neck, thorax, abdomen/pelvis and musculoskeletal system/extremities (parts of the extremities included in the scan). At the beginning of the study, the authors EKK and MHM defined four categories of urgency for the IFs. Category 1 included findings requiring urgent treatment/further examinations during or shortly after the hospital stay (eg, kidney lesion suspicious for renal cell carcinoma). Category 2 included findings requiring less urgent work-up or a follow-up within 3–6 months (eg, liver adenoma). Category 3 grouped findings which were most likely asymptomatic but potentially could become relevant in the future (eg, diverticulosis without signs of acute inflammation or prostate hyperplasia). Category 4 encompassed findings that were harmless and of no further consequence (eg, liver haemangioma or benign kidney cysts).

Prior studies mostly used only three categories (high urgency/follow-up/no further consequence).[13–18] We also defined one category of high urgency (category 1) and a category of no further consequence (category 4). However, we believe that allocating IFs that might become symptomatic in the future (eg, diverticulosis) into the same category, with findings with no further consequence (eg, healed bone fracture)—as suggested by a three-tiered categorisation scheme—does not sufficiently reflect the required medical management and communication. The primary care physician should be informed about any potentially relevant findings, and we therefore defined a category of IF with follow-up within 3–6 months (category 2; action by the primary care physician required) and a category of IF that might become symptomatic in the future (category 3; no need for action).

After defining the categories, the radiologists' reports were examined for IFs, which were then assigned to one of the categories by EKK. In a second step, the categorisation was double-checked by MHM. Cases in which an assignment was not immediately obvious or in which the investigators disagreed, published guidelines,[20] the Merck Manual (professional version)[21] and current literature were extensively reviewed. Our retrospective analysis was reviewed and approved by the local ethics committee.

Table 1 Polytrauma patients and incidental findings (IFs) in whole-body CT

	Patients (n)	Mean age (years)	Patients with IF (n)	Total IF (n)
Men	1735	44.1	1302	3740
Women	705	47.6	536	1700
Total	2440	45.1	1838	5440

STATISTICAL ANALYSIS

Our primary outcome was the proportion of patients with IFs, and the total number and category of these findings among the scanned patients. The following variables for analysis were used: 'age' (in years), 'sex' (male/female), 'number of IFs' and 'severity of IFs' (categories 1–4).

Age (years) and number of IFs were checked for normal distribution using exploratory data analysis. We performed a Kolmogorov-Smirnov test and a Shapiro-Wilk test. Neither of the two variables was normally distributed.

We applied a Kruskal-Wallis test to investigate the relation between age and severity of the IFs separately for women and men. Similarly, we investigated the relation between age and number of IFs. All statistics were calculated with SPSS (IBM, Version 22.0).

RESULTS

Of 99679 patients seen in our level-1 emergency department from 2009 to 2013 for any kind of trauma, 2440 (2.4%) had suffered multiple trauma and had undergone a WBCT scan. Traffic accidents (1310 of 2440 patients) and falls (891 of 2440 patients) were the major trauma mechanisms attended so far. The overall mean age of these 2440 patients with polytrauma (71.1% male, 28.9% female) was 45.1 years (range: 3 months to 98 years) (table 1).

Table 2 Number of incidental findings (IFs) in various body regions and number of patients with findings in the respective region

	IF		Patients*	
Body region	n	%	n	%
Head	1055	19.4	847	34.7
Neck	235	4.3	224	9.2
Thorax	1118	20.6	710	29.1
Abdomen/pelvis	2314	42.5	1238	50.7
Musculoskeletal/ extremities	718	13.2	542	22.2
None			602	24.7
Total	5440	100		

*Many of the affected 1838 patients had more than one IF.

Altogether, 5440 non-traumatic IFs were identified in 1838 of the 2440 (75.3%) patients, that is, on average almost 3 IFs per patient. Only 602 (24.7%) patients were without any IF (tables 1 and 2).

Of the 5440 IFs, 42.5% were documented in the abdomen/pelvis, approximately 20% in the head and 20% in the thorax. The remaining IFs were observed in the neck (4.3%) and the extremities (13.2%; table 2).

Importantly, among all patients, 8.4% had IFs classified as category 1 (urgent treatment/further examination) and 31.4% IFs classified as category 2 (follow-up within 3–6 months; table 3). Thus, approximately 40% of all patients had IFs requiring either immediate or delayed treatment/follow-up. The remaining patients had findings of lower urgency grouped in category 3 (findings with potential relevance in the future) and category 4 (harmless findings, age-related findings; table 3). The number and nature of all IFs in each category is listed in the online supplementary table.

The most-frequent category 1 findings were lesions suspicious for malignancy or definite malignancies (6 in the head, 6 in the neck, 52 in the thorax, 54 in the abdomen and 13 in the musculoskeletal system/extremities, 131 in total; marked with * in the online supplementary tables). Second-most frequent category 1 findings were signs of inflammation (3 in the head, 57 in the thorax, 24 in the abdomen, 84 in total, marked with # in the online supplementary tables).

Both in men and women, IFs increased significantly with age ($p<0.001$), as did the severity of IFs ($p<0.001$). The mean age for each category and the number of IFs are given in table 4. There was no significant difference in the number and severity of IF between men and women.

Table 3 Distribution of incidental findings (IFs) with regard to the severity

	IF		Patients with a given category IF*	
	n	%	n	%
Category 1†	279	5.1	204	8.4
Category 2	1251	23.0	766	31.4
Category 3	1938	35.6	1236	50.7
Category 4	1972	36.3	1173	48.1
Total	5440	100		

*Some patients had more than one IF.
†Category 1: urgent treatment or immediate work-up needed; category 2: further examination and follow-up within 3–6 months; category 3: findings potentially symptomatic in the future; category 4: harmless findings.

Table 4 Incidental findings (IFs) stratified by sex and age

	Mean age (years)			Mean age (years)	
Category	Female	Male	IF (n)	Female	Male
Category 1	61.9	59.5	>6	76.6	71.9
Category 2	61.1	54.2	5–6	69.6	58.8
Category 3	43.4	42.1	3–4	55.0	51.9
Category 4	40.5	39.6	1–2	42.2	40.3
No IF	32.9	33.8	0	32.9	33.8

DISCUSSION

In this study of 2440 patients undergoing WBCT after multiple trauma, 8.4% had an IF of high urgency (mostly indicative of malignancy or inflammation), and further 31.4% had IFs requiring follow-up in the near future. Most IFs were seen in the abdomen/pelvis, followed by the thorax. We found a significant increase in number and severity of IFs with the age of the patient.

Comparisons with other WBCT trauma studies are difficult because of variable study designs and differing categorisation schemes for IFs. However, all studies included a category of acute relevance. The frequency of patients falling into this category (5.6%–6.7%)[15–18] in these (small-scale) studies is well in line with our own study (8.4%). The only other large-scale study with 3092 patients by Barrett *et al*[11] found IFs of high urgency in 32% of patients, but this was due to a different categorisation scheme, which combined IFs corresponding to our categories 1 and 2 (in our study 39.8%).

We found a very clear correlation between age and increasing frequency of IFs. The rate of IFs did not differ between males and females in our study, in line with previous reports.[19 22] In contrast, Barrett *et al*[11] and Paluska *et al*[14] found more IFs of high urgency in female patients.

In addition to previous studies, we analysed the relative distribution of IFs in various body compartments. Most IFs were identified in the abdomen/pelvis (42.5%) and the thorax (20.6%). Also, 87% of the most-urgent category 1 IFs were found in thorax and abdomen/pelvis combined. This high incidence should have implications in the management of patients with polytrauma in the period following the acute treatment phase (ie, scheduled involvement of a pulmonologist and/or an abdominal surgeon).

We chose to use four categories of IFs. Previous studies usually have differentiated three categories or less.[11 13–18] All studies considered high-urgency IFs. Most studies also had a category of IF requiring a follow-up within 3–6 months. As far as the less-urgent IFs are concerned, we believe that only one additional category (as used in most publications with three different categories) does not suffice. For example, cholecystolithiasis or diverticulosis (category 3) can become symptomatic, whereas a healed fracture or an uncomplicated renal cyst (category 4) are of no further consequence. Such a differentiation appears to be relevant in the communication with the primary care physician to facilitate his diagnosis once the conditions become symptomatic.

The communication of IFs to the primary care physician has proven to be insufficient.[13 22] Several authors have suggested to employ dedicated personnel to ensure a sufficient communication.[11 14 23] Another possible future solution could be structured information in electronic discharge papers. This aspect appears quite important for the welfare of the patient and has also medicolegal implications.

Our study has limitations that deserve discussion. It is a single-centre, retrospective study in a level-1 trauma centre, so the results might not apply to hospitals with a different patient population. Furthermore, CT reports and not the original images were analysed for the documentation of IFs. This may have resulted in a systematic under-reporting of IFs, if they were not recorded by the radiologist performing the examination. Moreover, as many different radiologists were involved in the reporting during the investigation period of 5 years, a certain heterogeneity in reporting of IFs was noted. In most of our cases, it remained unknown if the IFs were already known by the patient. Follow-up of IFs was not investigated in this study. While certain findings have a highly characteristic CT appearance, the final histological diagnosis may still be different in some cases. This may have resulted in over-reporting of some findings, for example, of malignancy based on CT appearance alone.

Finally, since categorisation of IFs is not generally standardised, the assignment of some of the 236 types of IFs in our study (see online supplementary table), which was based on treatment guidelines and current literature, will partly differ from other studies. In fact, the classification of IFs is different in every published analysis so far. Nevertheless, and most importantly, our results regarding the frequency of urgent category 1 IFs were very similar to comparable studies (see above).

CONCLUSIONS

WBCT revealed a considerable number of IFs in a large study population including more than 2400 patients with polytrauma. Our findings suggest that approximately 1 in 10 patients can be expected to have an IF that requires immediate treatment or prompt work-up. This high frequency of IF places a major additional burden on the trauma surgeon in charge, necessitates interaction with other medical departments and requires a structured procedure to inform the primary care physician.

Contributors EKK: planned the study, data collection, statistical analysis, wrote main part of the manuscript. GW: planned the study, data analysis, helped writing the manuscript. IS: statistics expert, planned and controlled the statistics. TS: planned the study, data analysis, helped writing the manuscript. FS: helped with data acquisition. BH: provided the infrastructure for the study. MHM: planned the study, data collection, statistical analysis and wrote part of the manuscript.

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