Prospective audit of cross-sectional imaging and radiation exposure in general surgical patients

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ABSTRACT

INTRODUCTION Most patients admitted with an acute surgical problem undergo some imaging during their in-patient stay. As computed tomography (CT) scanning becomes more readily available, it is becoming the mainstay of assessment. Recent studies have commented on the potential adverse effects of early cross-sectional imaging. This audit aimed to determine the use of early cross-sectional imaging and associated radiation dose in an acute surgical cohort.

PATIENTS AND METHODS Data from 500 acute surgical patients were prospectively collected over a 3-month period. CT scans were undertaken, the effect on subsequent diagnostic and management decisions and the potential associated risks were evaluated.

RESULTS Almost 40% of subjects underwent CT scanning. Of these, 20% did not alter management and could be deemed unnecessary. The radiation exposure equated to an age- and gender-specific risk of fatal cancer induction between 1 in 1675 and 1 in 7130.

CONCLUSIONS Early-cross sectional imaging provides a valuable diagnostic adjunct. Decisions to expose patients to potentially hazardous radiation need to acknowledge the anticipated benefits versus risks.

KEYWORDS

Computed tomography – Cross-sectional imaging – Diagnostic – Benefit–risk analysis

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The advent of computed tomography (CT) has undeniably brought with it great benefits to medicine: patients who may once have required laparoscopy or laparotomy can be investigated with a non-invasive, painless and often more accessible modality. Routine assessment of the patients admitted with acute abdominal pain frequently requires imaging. In addition to plain radiography, early CT is being used more frequently. Ng *et al.*¹ have already identified the potential advantage of early CT in acute surgical admissions – namely reductions in hospital stay and possibly mortality. This supports the observations of Siewert *et al.*,² who concluded CT was superior to clinical examination for reaching a diagnosis in patients with abdominal pain.

With greater accessibility for more detailed imaging modalities – there are currently eight CT scanners for every million of the population³ – there remains a need to ensure there is just clinical indication for every investigation requested. Doctors' awareness of potential radiation exposure is limited – just 6% of consultants and their trainees could accurately define dose from CT (up to 300–400 times that of a standard chest X-ray) and 97% underestimated the

radiation exposure from all imaging modalities.⁴ Although, comprising just 4% of radiological examinations, CT contributes almost 40% of radiation dosage⁵ of all imaging undertaken. The former National Radiological Protection Board,⁶ now the Health Protection Agency (HPA) estimates between 100–250 deaths each year are related to malignancy secondary to radiation exposure. Guidelines for the appropriate use of computed tomography from the Ionising Radiation (Medical Exposure) Regulations Board⁷ in conjunction with those from the HPA aim to minimise unnecessary scanning.

Patients and Methods

Age, gender, initial diagnosis, final diagnosis and length of hospital stay were prospectively recorded for 500 consecutive patients admitted to a tertiary referral surgical unit over a 3-month period (March–May 2008). Inclusion criteria were: (i) patients aged 16 years and above; and (ii) admitted as part of the general surgical 'take' with an acute surgical problem. At the end of the audit period, every CT scan was

Figure 1 CT scans.

reviewed to determine whether it was necessary. CT imaging was deemed to be unnecessary in the event a single unifying diagnosis was made following initial assessment by the admitting junior doctor and confirmed by a senior registrar or consultant whereby imaging neither altered the diagnosis nor management and where there were no additional indications for CT.

For those CT scans identified as unnecessary, CTDI (dose index) and DLP (dose length product) were recorded with the exception of two cases where data were not available. The DLP (an approximation of the total energy a patient absorbs) was subsequently multiplied by a factor of 0.017 to calculate effective dose as per the European guidelines on quality criteria for CT⁸ and doses were then grouped according to age and gender and a mean value calculated.

Results

Table 1 summarises the patient demographic data. Of the 500 admissions during this period, 198 patients (39.6%) underwent CT imaging yielding 151 positive scans (Fig. 1).

Almost a quarter (23.7%) of scans identified no abnormality. Large bowel pathology (obstruction, diverticulitis, colitis and perforation) was the second most common finding. Small bowel abnormalities included ileitis, perforation and obstruction comprised 8% of scans while just under a fifth fell into the category of 'other' – renal calculi, ovarian cysts, traumatic fractures, postoperative complications.

Using the aforementioned criteria, 41 of the 198 scans (20.7%) undertaken were deemed unnecessary. From DLP values and age- and gender-specific risk tables, a final mean risk was calculated (Table 2).

Risk of fatal cancer induction was most pronounced in females under the age of 20 years culminating in a risk of 1 in 1675. This risk fell to 1 in 7130 in females over the age of 80 years.

Table 1 Patient demographic data

Gender (M:F)	222 (44.4%):278 (55.6%)
Mean age, years (range)	50.4 (16–94)
Mean LOS, days (range)	4.25 (1–30)
Diagnosis, <i>n</i> (%)	
Pancreatitis	26 (5.2)
Biliary pathology	56 (11.2)
Appendicitis	63 (12.6)
Bowel obstruction	45 (9)
Peptic ulcer disease	16 (3.2)
Diverticular disease	33 (6.6)
Postoperative complications	18 (3.6)
No diagnosis made	66 (13.2)
Transferred speciality	23 (4.6)
Other	154 (30.8)
Mortality, <i>n</i> (%)	9 (1.8)

Each year there are 1,505,941 general surgical admissions in England⁹ comprised of 542,618 emergencies and 963,323 elective patients. Given the above figures, this equates to induction of a fatal cancer as a consequence of unnecessary CT in 81 men each year (53% admissions are male) and 69 women.

Discussion

CT scanning has indisputably facilitated many diagnostic

Table 2 Risks of fatal cancer induction

Age at exposure (years)	Cases (<i>n</i>)	Mean effective dose (mSv)	Risk for 1 mSv effective dose	Dose attributable risk
Female				
20	2	7.761	1 in 13,000	1 in 1675
30–50	9	8.157	1 in 20,000	1 in 2452
60	6	8.143	1 in 25,000	1 in 3070
70	7	7.780	1 in 32,000	1 in 4113
80	2	7.013	1 in 50,000	1 in 7130
Male				
20	0		1 in 20,000	
30–50	10	9.902	1 in 25,000	1 in 2523
60	2	8.211	1 in 32,000	1 in 3897
70	0		1 in 40,000	
80	1	15.62	1 in 67,000	1 in 4289

and management decisions particularly with regards to surgical patients. However, with an increased propensity to perform CT, we must ensure the potential diagnostic benefits outweigh the risks. Figures from the US from 2007 suggest 19,500 CT scans were undertaken each day¹⁰ – the equivalent radiation dosage of up to 5,850,000 chest radiographs.

Solid cancers and leukaemia occurring as a consequence of exposure to low-dose ionising radiation has previously been documented; the BEIR VII phase 2 report¹¹ identified subgroups with previous exposure and outlined those malignancies which could directly be attributed to previous exposure. In a recent study, Berrington de Gonzalez *et al.*¹² attempted to quantify the exact risk of CT. Disregarding those who had already been diagnosed with cancer and those performed in the last 5 years of life, they suggest almost 29,000 future cancers could occur as a direct consequence of imaging. Over a 20–30-year period (assuming a 50% mortality), this equates to 15,000 deaths annually.

Fazel *et al.*¹³ reported data on 952,420 patients across five centres in the US assessing exposure to ionizing radiation. They found during the 3-year study period, almost 70% underwent imaging of some description, 75.4% of cumulative effective dose comprising of CT and nuclear imaging. Although they identified a relatively small increase in risk compared with background exposure, the cumulative nature needs to be borne in mind, particularly for younger patients and those who undergo repeated investigation.

Data from four centres in California reported by Smith-Bindman *et al.*¹⁴ looked at all CT scans undertaken in a 5-month period and equated DLP data to the risk of malignancy also accounting for sensitivities of differing organs to developing radiation-induced cancer.¹⁵ Data demonstrated great variability with regards radiation doses – a multiphase abdominopelvic CT scan in most centres utilised an effective dose of 31 mSv compared with one centre reporting doses of up to 90 mSv. This highlighted the need to adhere to a strict protocol ensuring greater uniformity with regards radiation exposure. They also identified a proportion of patients, who are young and otherwise fit and well, presenting with self-limiting illnesses and undergoing unnecessary imaging.

It needs to be acknowledged there are various limitations to this study particularly with regards to assessment of necessity of CT scanning – this was a subjective measure made retrospectively once all investigations, clinical and operative findings were known. This was reliant on the judgement of the authors and was potentially open to much variability.

Despite this, there is still mounting evidence to support comprehensive patient assessment of the need for imaging before proceeding to CT. Requesting doctors must allow patients to make an informed decision, part of which is knowing the exact nature of the risk the patient is being exposed to. There are already a number of papers questioning the exact diagnostic role of CT, particularly with regards to children¹⁶ and, although it has an integral role in medical diagnostics, we must not forget its potential carcinogenic effects.

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