Evaluation of the utility of abdominal CT scans in the diagnosis, management, outcome and information given at discharge of patients with non-traumatic acute abdominal pain

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Objectives: The role of CT imaging in the diagnosis and management of acute abdominal pain is well established, but its utility is limited in a minority of cases. The aim of this study was to quantify the degree to which radiological and clinical findings differ. Interobserver variability in CT reporting was also assessed.

Methods: Clinical data and CT reports were analysed retrospectively for any discrepancies by comparing CT diagnosis, clinical diagnosis as stated on the discharge summary and final diagnosis (based on consensus review of all information). Blinded review of all CT imaging was performed to determine interobserver variability.

Results: 120 consecutive scans fulfilled the inclusion criteria (114 patients; 79 women; mean age 55 years). The correct clinical diagnosis was made in 87.5% of cases based on CT findings. The lack of intravenous contrast limited diagnostic interpretation in 6 of the 15 discrepant cases. CT was unable to define early inflammatory changes in three patients and early caecal carcinoma in one. A right paraduodenal internal hernia was difficult to detect in another patient. Interobserver agreement was 93%, but with a low kappa value of 0.27. A paradox exists due to an imbalance in the positive and negative agreement of 96% and 31%, respectively.

Conclusions: The utility of CT imaging in the diagnosis and management of patients presenting with acute abdominal pain is confirmed, but is limited in a minority of cases where poor negative interobserver agreement exists. Good communication to the reporting radiologist of the relevant patient history and clinical question becomes important.

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Acute abdominal pain may still present a diagnostic dilemma for clinicians. The accuracy of clinical assessment is variable (47–76%), and depends upon clinical experience and whether laboratory data are available [1, 2].

For this reason, there has justifiably been an increasing reliance on CT imaging to guide management; the role of intravenous (i.v.) contrast-enhanced CT is well established, with evidence demonstrating improved speed and accuracy of diagnosis, with resultant reduction in hospital admission rates and length of stay, as well as reduced morbidity and mortality [2–8]. In a minority of cases, the utility of CT is more limited, especially in the diagnosis of early inflammatory changes such as in inflammatory bowel disease, mesenteric ischaemia and mild acute pancreatitis, and in patients who have a history of chronic abdominal disease, with disagreement between the radiological and clinical diagnoses more likely [4–7, 9, 10].

This study aims to quantify the degree to which radiological and discharge diagnoses may differ in a consecutive series of patients with non-traumatic

abdominal pain. The secondary aim includes determining the consistency of consultant radiologist CT reporting by analysing interobserver variability.

Methods and materials

Patients

This project was registered with the hospital audit department and permission was given to review the patient data. Ethics approval was not required as it was considered part of the departmental audit.

This retrospective study was conducted at an urban (inner city) university-affiliated foundation trust hospital serving an ethnically diverse but predominantly young migrant population. The hospital has approximately 400 adult beds, admits 40 000 people and treats over 110 000 people in the accident and emergency department per year.

Between March 2009 and September 2009, all patients with symptoms of acute severe abdominal pain (with positive signs on clinical examination most commonly guarding and peritonism) and who were referred for an urgent CT scan as part of their evaluation were included in the study. CT scans performed within a 24-h period of

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Table 1. Distribution of cases by disease according to post-CT diagnosis

Post-CT diagnosis	Number of patients out of 120 cases	Proportion (%)
Hepatobiliary disease	7	5.8
Pancreatic disease	4	3.3
Digestive tract disease	52	43.3
Large bowel obstruction	10	8.3
Small bowel obstruction	10	8.3
Dilated bowel of unknown aetiology	3	2.5
Colitis	8	6.7
Acute diverticulitis	5	4.2
Ischaemic bowel	1	0.8
Acute appendicitis	6	5.0
Perforation of digestive tract	9	7.5
Urinary tract disease		
Acute pyelonephritis	1	0.8
Gynaecological disease	4	3.3
Mixed pathology		
Small bowel obstruction and biliary obstruction	2	1.7
Post-surgical complications	5	4.2
Haematoma	3	2.5
Anastomotic leak	1	0.8
Perforated bladder	1	0.8
Other disease	14	11.7
Abdominal or pelvic collections	2	1.7
Hernia	5	4.2
Disseminated metastatic disease	4	3.3
Basal pneumonia	1	0.8
Ruptured abdominal aortic aneurysm	2	1.7
Normal CT/no cause found	31	25.8

the radiology request were defined as urgent. Patients with acute abdominal pain secondary to trauma (blunt or penetrating) and patients who were referred for a non-contrast CT of the kidneys, ureter and bladder (CT KUB) to establish the clinical diagnosis of renal colic were excluded.

Imaging protocol

CT scans were performed on a Toshiba Aquilion 64 scanner (Toshiba, Otawara, Japan) and acquired in the portovenous phase at 60 s after i.v. contrast administration (Omnipaque 300 at 3 ml s⁻¹; GE Healthcare, AS, Oslo, Norway). Oral contrast agent [1000 ml of 2% Gastrografin® (Bracco Diagnostics Inc., Princeton, NJ), 20 ml Gastrografin per litre of water; Bayer, Newbury, UK] was administered 1 h prior to the scan. The scan was reconstructed to create contiguous 5 mm axial sections from the lung bases to the pubic symphysis. Coronal and sagittal reconstructions were also made available.

Data analysis

All scans performed in and out of hours were reported only by a consultant radiologist. CT diagnosis (as reported

by the duty consultant radiologist with the support of the clinical information provided by the clinician on the request form) and the discharge diagnosis (as stated on the discharge summary) were compared. Discharge diagnosis was based on clinical examination, laboratory data and results of all imaging studies, including CT, patient management and outcome.

If the CT diagnosis correlated with the discharge diagnosis, the final diagnosis was assumed correct and no further review taken. The radiology images and medical records of all discrepancies were scrutinised by a consultant radiologist and consultant general surgeon. Such scrutiny resulted in the creation of a final diagnosis that may or may not have differed from the discharge diagnosis. Ideal therapeutic management was then determined by clinical course, surgical, histopathological and (in the case of death) post-mortem findings.

The CT and discharge diagnoses were compared with the final diagnosis and assessed as: (i) correct, when the CT/discharge diagnoses matched the final diagnosis; (ii) non-specific, when the CT/discharge diagnosis listed the final diagnosis within the differential diagnosis; and (iii) incorrect, when the CT/discharge diagnosis did not match the final diagnosis and was not mentioned within the differential diagnosis. The therapeutic management actually performed was correlated with the ideal therapeutic decision.

Radiological review of all 120 CT scans was performed where only clinical information provided on the original radiology request form was made available to the blinded consultant radiologist. Only discrepancies between the CT diagnosis and blinded CT diagnosis were reviewed by consensus between the two consultant radiologist authors. Interobserver agreement in CT reporting was determined by κ analysis. Positive and negative agreement in CT reporting was also determined. κ -values >0.81, 0.61–0.8, 0.41–0.60, 0.21–0.40 and 0–0.2 indicate almost perfect, substantial, moderate, fair and slight agreements, respectively.

Results

120 consecutive CT scans (114 patients; 79 women; mean age 55 years, range 14–95 years) were included in the study. Six patients had a repeat scan; four patients were readmitted after discharge with acute abdominal pain; one patient acutely deteriorated during admission and required an urgent repeat CT scan; and one patient had persistent acute abdominal pain of uncertain aetiology and required a repeat CT scan with contrast (the first CT scan was performed without contrast and was unhelpful). 25 scans were referred directly from the accident and emergency department, and 95 following admission. I.v. contrast was not administered in 21 scans (in 20 cases the patients had impaired renal function and in 1 the patient refused contrast as she was breast-feeding). The CT diagnoses are summarised in Table 1. The three most common diagnoses included "normal/no cause found" (25.8%), small bowel obstruction (8.3%) and large bowel obstruction (8.3%).

Table 2. Discrepancies between CT/discharge diagnosis and final diagnosis

i.v. contrast given	Oral contrast given	CT diagnosis	Discharge diagnosis	Final diagnosis	CT diagnosis assessed	Discharge diagnosis assessed	Actual management	Management appropriate?	Ideal management	Patient deceased related to admission?
<i>Radiological misses</i>										
No	Yes	Sigmoid colitis	Perforated sigmoid	Perforated sigmoid	Incorrect	Correct	Surgical	Yes		No
Yes	Yes	Mechanical large bowel obstruction	Pseudo-obstruction	Pseudo-obstruction	Incorrect	Correct	Surgical	No	Conservative	No
No	No	Large bowel obstruction	Caecal perforation	Caecal perforation	Incorrect	Correct	Surgical	Yes		Yes
Yes	No	No cause found on CT	Large bowel obstruction of unknown aetiology	Ischaemic colitis	Incorrect	Non-specific	Conservative	Yes		No
No	No	Diverticulitis with abscess	Caecal tumour	Caecal tumour	Incorrect	Correct	Surgical	Yes		Yes
<i>Clinical misses</i>										
Yes	Yes	Pelvic inflammatory disease	Acute appendicitis	Pelvic inflammatory disease	Correct	Incorrect	Surgical	Yes		No
Yes	No	Pelvic inflammatory disease	Acute Appendicitis	Pelvic inflammatory disease	Correct	Incorrect	Surgical	No	Conservative	No
Yes	Yes	Acute appendicitis	Inflammatory bowel disease, tuberculosis or parasitic infection	Acute appendicitis	Correct	Incorrect	Conservative	Yes		No
Yes	Yes	Acute appendicitis	Non-specific abdominal pain	Acute appendicitis	Correct	Incorrect	Conservative	Yes		No
No	No	Large hiatus hernia	Acute pancreatitis	Respiratory compromise secondary to very large hiatus hernia	Correct	Incorrect	Conservative	Yes		Yes
No	No	Inflammatory colitis	Diverticulosis	Inflammatory colitis	Correct	Incorrect	Conservative	Yes		No
No	No	Fat necrosis	Non-specific abdominal pain	Fat necrosis	Correct	Incorrect	Conservative	Yes		No

Table 2. Continued

i.v. contrast given	Oral contrast given	CT diagnosis	Discharge diagnosis	Final diagnosis	CT diagnosis assessed	Discharge diagnosis assessed	Actual management	Management appropriate?	Ideal management	Patient deceased related to admission?
Yes	No	Large bowel obstruction secondary to inflammatory bowel disease, ischaemic colitis, diverticulitis	Large bowel obstruction secondary to multiple adhesions	Large bowel obstruction secondary to diverticulitis	Non-specific	Incorrect	Surgical (adhesiolysis)	No	Surgical (sigmoid colectomy)	No
<i>Radiological and clinical misses</i>										
No	No	Dilated bowel of unknown aetiology	Ischaemic colitis	Right paraduodenal internal hernia	Incorrect	Incorrect	Conservative	No	Surgical	Yes
No	No	Dilated bowel of unknown aetiology	Ischaemic colitis	Right paraduodenal internal hernia	Incorrect	Incorrect	Conservative	No	Surgical	Yes

In 105 out of 120 scans (87.5%), the CT diagnosis matched the discharge diagnosis with the CT diagnosis of pathology correct in 91 cases (non-specific in 14 cases). Of these, the final diagnosis was confirmed surgically in 23 patients, by interventional radiology in 3 patients and by both interventional radiology and surgery in 1 patient.

CT diagnosis vs final diagnosis

The 15 discrepancies between the CT diagnosis and the discharge diagnosis are summarised in Table 2. Of these, the CT diagnosis was correct in eight (non-specific in one case) when compared with the final diagnosis. In five of the seven true discrepancy cases, imaging was performed without intravenous contrast and included the following: perforated caecum, confirmed at surgery; caecal tumour, confirmed by histopathology; on two separate scans for the same patient, right paraduodenal internal hernia confirmed at post-mortem, which had been reported as small bowel obstruction at CT; and perforated sigmoid colon (as confirmed at surgery), which was missed and reported as sigmoid colitis (Figure 1).

In one of the two remaining cases where examinations were performed with intravenous contrast, the discharge diagnosis of pseudo-obstruction (as confirmed at surgery) was misinterpreted as mechanical large bowel obstruction on CT. In the other, ischaemic bowel was not reported.

Discharge diagnosis vs final diagnosis

Within the limitations of clinical documentation, among the 15 discrepancies, the discharge diagnosis was correct in 5 cases (non-specific in 1 case). Of the 10 incorrect cases, the discharge diagnosis differed from the final diagnosis on the basis of histological review in 4 cases, of which (i) 2 patients labelled with appendicitis had pelvic

Figure 1. Selected axial CT image following intravenous contrast showing perforated sigmoid diverticulitis which was incorrectly reported as a sigmoid diverticulitis. On blinded retrospective review, free locules of intraperitoneal gas are identified between the uterus and rectum (straight white arrow).

Table 3. Discrepancies from interobserver variability in CT reporting analysis

CT diagnosis	Blinded radiological review	Consensus
<i>Blinded radiological review correct</i>		
Sigmoid colitis	Perforated sigmoid colitis	Perforated sigmoid colitis
Mechanical large bowel obstruction	Pseudo-obstruction	Pseudo-obstruction
Cholecystitis with abscess	Cholecystitis but no abscess	Cholecystitis but no abscess
Sigmoid diverticulosis and abscesses	Focal duodenal perforation and abscesses	Focal duodenal perforation and abscesses
Diverticulitis with abscess	Abnormal bowel and right iliac fossa collection. Differentials include infection or neoplasia	Abnormal bowel and right iliac fossa collection. Differentials include infection or neoplasia
Biliary obstruction	Tumour encasing the inferior vena cava with obstruction of the transjugular intrahepatic portosystemic shunt with resultant biliary obstruction	Tumour encasing the inferior vena cava with obstruction of the transjugular intrahepatic portosystemic shunt with resultant biliary obstruction
Sigmoid colitis	Localised perforated sigmoid diverticulitis	Localised perforated sigmoid diverticulitis
<i>Blinded radiological review incorrect</i>		
Obstructive bowel cancer	Bowel cancer but no bowel obstruction	Hepatic flexure tumour with localised perforation, bowel obstruction and regional change
Small bowel obstruction	Ischaemic bowel	Right paraduodenal internal hernia evident with the benefit of histopathological findings
Small bowel obstruction	Ischaemic bowel	Right paraduodenal internal hernia evident with the benefit of histopathological findings
Acute pancreatitis	Duodenal perforation	Acute pancreatitis with possible secondary duodenitis

Table 4. Agreement between the duty and the blinded consultant radiologist

Duty consultant radiologist	Blinded consultant radiologist		
	CT diagnosis agrees with consensus	CT diagnosis disagrees with consensus	Total
CT diagnosis agrees with consensus	109	2	111
CT diagnosis does not agree with consensus	7	2	9
Total	116	4	120

inflammatory disease, but the histopathological findings were not acknowledged by the clinicians in the notes or discharge summary; and (ii) for 2 scans performed on the same patient (see above), the post-mortem diagnosis was a right paraduodenal internal hernia but the discharge diagnosis was ischaemic colitis.

In five cases, the final diagnosis differed from the discharge diagnosis as follows: (i) the surgical finding of adhesional large bowel obstruction and so stated in the discharge summary was in fact due to large bowel obstruction secondary to sigmoid diverticulitis; (ii) a discharge diagnosis of non-specific abdominal pain was in fact medically treated acute appendicitis; (iii) a discharge diagnosis of simple diverticulosis was in fact due to colitis; (iv) a discharge diagnosis of acute pancreatitis was in fact respiratory failure due to compression of the lungs by intrathoracic stomach and bowel; and (v) a discharge diagnosis of inflammatory bowel disease or parasite/tuberculosis infection was in fact acute appendicitis. These five discrepancies are largely due to clinical inexperience and misinterpretation of the clinical history, examination findings, laboratory and radiological findings. In one case, a discharge diagnosis of muscular pain was in fact intra-abdominal fat necrosis as reported on the CT. This radiological finding was again not acknowledged in the notes or discharge summary.

Actual management vs ideal management

There were only the five discrepancies (of which two scans were performed for the same patient):

(1–2) the patient who died of ischaemic bowel should have been operated on early in his admission

Figure 2. Selected axial CT image obtained following intravenous and oral contrast showing a contained perforated sigmoid diverticulitis which was incorrectly reported as a sigmoid diverticulitis. Again, on blinded retrospective review, a locule of gas is seen to lie outside the sigmoid bowel wall in the adjacent mesenteric fat (straight white arrow).

Figure 3. Selected coronal CT image obtained following intravenous and oral contrast. On this, a right sided intra-abdominal collection was incorrectly reported (long white arrow). On retrospective blinded review, this was confirmed to be a fluid filled terminal ileum by the presence of a fatty ileocaecal valve more proximally (short white arrow).

(3) the patient in whom emergency adhesiolysis was performed should have had a sigmoid colectomy

(4) one of the two patients (as discussed in the previous section) in whom a normal appendix was removed should most definitely have been treated conservatively (as an iatrogenic injury to the sigmoid colon was incurred during surgery)

(5) the patient who underwent an emergency laparotomy should have undergone endoscopic decompression.

Interobserver variability in CT reporting

The only information made available to the blinded consultant radiologist was the original request form. Of

the 120 scans, there were 11 discrepancies. These are summarised in Table 3. Two image examples illustrate the incorrectly reported sigmoid colitis (Figure 2) and abscess formation (Figure 3) by the duty consultant radiologist. Agreement between the duty consultant radiologist and the blinded consultant radiologist is summarised in Table 4. Based upon the assumption that the final diagnosis was correct if the CT diagnosis correlated with the discharge diagnosis, there was an overall interobserver agreement of 93%, but a κ -value of 0.27 (95% confidence interval -0.18 to 0.73) between the blinded consultant radiologist and the duty consultant radiologist who had originally reported the acute abdominal CT scan. Detailed analysis showed an interobserver positive agreement of 96% but a low interobserver negative agreement of 31%.

Discussion

The usefulness of CT in the diagnosis and management of acute abdominal pain is well established [2–8], and confirmed by the results of this study, in which the CT diagnosis correlated with the final diagnosis in 87.5%. The interobserver agreement of 93% also compares favourably [11], although, statistically, agreement was only fair. The reason for this paradox is probably due to an imbalance in the positive and negative agreements, with a result of 96% and 31%, respectively. These results can be interpreted as showing generally good agreement among the radiologists for the majority of scans. However, vast disagreement is seen in a minority of cases where the usefulness of CT becomes limited. In these few cases, the importance of good communication to the reporting radiologist of the relevant patient history and clinical question becomes important. The availability of laboratory data and patient notes, as well as an ability to contact clinicians and to confer with radiology colleagues, are also essential.

(a)

(b)

(c)

Figure 4. (a) Selected coronal CT images following intravenous contrast demonstrating a dilated loop of small bowel interposed between the right colon. (b) At post-mortem examination, there was herniation of the small bowel and the right colon posteriorly through a defect in the greater omentum in keeping with a right paraduodenal internal hernia (straight black arrow). There was also infarction of the ascending, transverse colon and small bowel. The internal hernia was difficult to identify even on retrospective review and with the benefit of the histopathology report and personal communication with the histopathologist. (c) Schematic diagram illustrating the herniation of the right colon (curved white arrow) and small bowel (straight white arrow) posteriorly through a defect in the greater omentum (*) as seen at post mortem examination.

The factors that limit the usefulness of CT can be summarised as follows.

Lack of contrast

The role of contrast-enhanced imaging in the detection of various pathologies is well reported, where certain conditions are only detectable following contrast administration or differentiated from other pathologies by the enhancement pattern. The interpretation of unenhanced scans also depends on the experience of the radiologist [12].

Early changes

Previous studies [4, 7, 9, 10] have identified false-negative CT reporting to result from an inability of CT to define early inflammatory change at a "mucosal" level (e.g. in patients with proven diverticulitis, acute pancreatitis or mesenteric ischaemia). This can be further compounded by lack of intravenous contrast. False-positive reporting has been noted in the detection of early caecal tumours. A study by Cai et al [13] has shown that only 13% of patients with caecal wall thickening on CT had a positive pathology on subsequent colonoscopy.

Uncommon conditions

Unfamiliar conditions are less likely to be considered within the differential when presented with non-specific imaging features. In the current study, the presence of a right paraduodenal internal hernia was difficult to identify even on retrospective review, and with the benefit of the histopathology report and personal communication with the histopathologist (Figure 4).

Internal hernias have an overall incidence of less than 1% and contribute up to 5.8% of all cases of intestinal obstructions. The incidence of internal hernias is increasing with newer surgical techniques (e.g. within bariatric surgery [14]). Left untreated, they are associated with high mortality rates.

Non-specific imaging findings

Many conditions may present with similar imaging features, necessitating the reporting radiologist to provide a broad differential that may be unhelpful to the clinician. Knowledge of the clinical, laboratory and imaging findings help narrow the differential diagnosis [15], but this relies upon clear communication between clinicians and radiologist. In this study, female patients who presented with right iliac fossa pain, despite the use of imaging, constituted a particular discrepancy between the discharge and final diagnoses. The reason for this is unclear, but may be due to interclinician variability in their interpretation of the CT reports, their correlation with clinical findings and their own clinical experience. However, a prospective study needs to be conducted to confirm these findings.

Conclusion

CT imaging in the diagnosis, management and outcome of patients presenting with acute abdominal pain is well established. In a minority of cases, the usefulness is limited by certain factors; specifically, the use of non-contrast imaging, the inability of CT to define various pathologies, the lack of imaging findings in uncommon conditions and the variability in the interpretation of non-specific imaging findings. Awareness of these limiting factors is vital to both clinicians and radiologists in the diagnosis and management of these patients.

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