Evaluation of early abdominopelvic computed tomography in patients with acute abdominal pain of unknown cause: prospective randomised study

Chaan S Ng, Christopher J E Watson, Christopher R Palmer, Teik Choon See, Nigel A Beharry, Barbara A Housden, J Andrew Bradley, Adrian K Dixon

Abstract

Objectives To evaluate the impact of early abdominopelvic computed tomography in patients with acute abdominal pain of unknown cause on length of hospital stay and accuracy of diagnosis.
Design Randomised, prospective controlled trial.
Setting Teaching hospital in England.
Participants 120 patients admitted with acute abdominal pain for which no immediate surgical intervention or computed tomography was indicated.
Intervention 55 participants were prospectively randomised to early computed tomography (within 24 hours of admission) and 65 to standard practice (radiological investigations as indicated).
Main outcome measures Length of hospital stay, accuracy of diagnosis, and, owing to a possible effect on inpatient mortality, deaths during the study.
Results Early computed tomography reduced the length of hospital stay by 1.1 days (geometric mean 5.3 days (range 1 to 31) *v* 6.4 days (1 to 60)), but the difference was non-significant (95% confidence interval, 8% shorter stay to 56% longer stay, P=0.17). Early computed tomography missed significantly fewer serious diagnoses. Seven inpatients in the standard practice arm died. Only 50% (59 of 118) of diagnoses on admission were correct at follow up at 6 months, but this improved to 76% (90) of diagnoses after 24 hours.
Conclusions Early abdominopelvic computed tomography for acute abdominal pain may reduce mortality and length of hospital stay. It can also identify unforeseen conditions and potentially serious complications.

Introduction

Acute abdominal pain is a common surgical emergency requiring admission to hospital. Initial assessment may yield a diagnosis, but more usually the cause is unclear and a period of observation, together with further radiological and laboratory investigation, is necessary. A correct diagnosis may emerge over time, but delays may result in inappropriate management, affecting both morbidity and mortality. Acute appendicitis, the commonest cause of acute abdominal pain, is incorrectly diagnosed in up to 35% of patients.[1] Inaccurate diagnosis may lengthen hospital stay, a major contributor to the costs of health care.

Computed tomography can diagnose a wide range of acute abdominal conditions, such as acute appendicitis, diverticulitis, renal tract calculi, pancreatitis, and small bowel obstruction.[1-11] However, few studies have examined the efficacy of computed tomography in patients with acute abdominal pain, and to our knowledge no randomised controlled trials have assessed its use as a diagnostic aid for acute abdominal pain.[12-14]

We aimed to determine if early computed tomography in patients with acute abdominal pain might reduce length of hospital stay and improve the accuracy of diagnosis. We did not anticipate an effect on mortality when the trial was designed, but some patients did die during the study. We therefore present the findings of this potentially important outcome measure.

Participants and methods

Our study was a prospective randomised controlled trial undertaken at a teaching hospital with over 1000 beds. All patients with acute abdominal pain admitted under the care of the surgical team from 9 am Friday to 5 pm Sunday, October 1999 to September 2000, were eligible for entry into our study. This period was chosen to enable access to imaging facilities within the time frame of our study. Patients were excluded if they were under 18 years of age, pregnant, or required emergency surgery (perforated viscus, acute appendicitis, etc) or urgent computed tomography (for example, abdominal trauma). Patients with rectal bleeding, suspected gynaecological disorders, or perianal abscesses were also excluded.

Interventions

Patients were randomised to current standard practice or to early computed tomography (within 24 hours of admission). Standard practice included plain radiography and, if appropriate, ultrasonography, computed tomography, and fluoroscopic investigations. At our hospital, ultrasonography, computed tomography, and fluoroscopic investigations are undertaken on an out

Department of Radiology, University of Cambridge, Addenbrooke's Hospital, Cambridge CB2 2QQ
Chaan S Ng *lecturer*
Teik Choon See *specialist registrar*
Nigel A Beharry *specialist registrar*
Barbara A Housden *superintendent radiographer*
Adrian K Dixon *professor*

Department of Surgery, Addenbrooke's Hospital
Christopher J E Watson *senior lecturer*
J Andrew Bradley *professor*

Centre for Applied Medical Statistics, Department of Public Health and Primary Care, University of Cambridge, Cambridge CB2 2SR
Christopher R Palmer *medical statistician*

Correspondence to: C S Ng, Department of Radiology, Box 57, MD Anderson Cancer Center, 1515 Holcombe Boulevard, Houston, TX 77030-4009, USA cng@mdanderson.org

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of hours basis only if clinically indicated and necessary for patient management.

Patients randomised to standard practice were not denied access to computed tomography if it was needed; if it was performed within 24 hours of admission it was classified as off-study computed tomography, and if it was performed more than 24 hours after admission it was classified as delayed computed tomography. Similarly, patients randomised to the early computed tomography arm were not denied access to other radiological investigations within the first 24 hours.

Protocol for computed tomography

Patients were given oral contrast medium (20 ml meglumine diatrizoate (Gastrografin; Schering, Berlin) in 500 ml water) 2 hours before computed tomography, rectal contrast medium (200 ml Gastrografin), intravenous contrast medium (100 ml iopamidol 300 mg/ml (Niopam; Bracco, High Wycombe)), and pump injection (2 ml/s, 70 second delay).

Helical computed tomograms (Somatom Plus; Siemens, Erlangen) were obtained from the diaphragm to the symphysis pubis, with a 10 mm collimation, 1.5 pitch, and 10 mm reconstruction interval. Computed tomography was reported by the on-call radiologist, who had scope to obtain additional images if necessary.

Length of hospital stay and diagnostic accuracy

We hypothesised that early computed tomography might reduce the length of hospital stay. We assessed this on a calendar day basis from the date of admission to the date of discharge. Thus an admission and discharge on the same calendar day was a one day stay.

We also hypothesised that early computed tomography might improve the accuracy of diagnosis. We reviewed patients' notes 6 months after admission to determine the final diagnosis, management, and investigations during admission and follow up.

Any changes in diagnoses and management were assessed blindly by two of us (CSN, CJEW) and scored by consensus. We defined a diagnosis that remained unchanged as "no change." In the event of change we assessed whether this was to a more severe diagnosis—requiring surgery or major change in management—or to a less severe diagnosis—for example, appendicitis to non-specific abdominal pain. Possible changes in diagnoses were assessed at two intervals: between the initial diagnosis and at 24 hours, and between the diagnosis at 24 hours and the final diagnosis (assessed after surgery or at 6 month follow up).

Randomisation

Patients were randomised to one of the two intervention arms once the surgeon had admitted them. Patients were invited by the surgical team to participate in the study and were randomised by the on-call radiologist, following a predetermined sequence derived from a random number algorithm. Participants were blinded to the randomisation sequence.

Our study was approved by the local research ethics committee. Informed written consent was obtained from all the patients.

Statistical analysis

To account for skewness, we log transformed data on length of hospital stay to normality before analysis. We give geometric means and comparisons made by Student's *t* test on the log scale. We also present untransformed means and medians, using the Mann-Whitney U test to compare groups. We tested the association between categorical variables with Fisher's exact test or between ordered categorical data with the χ^2 test for trend. We conducted analyses on both an intention to treat basis and an as treated basis. The as treated basis took account of patients originally randomised to standard practice but who had off-study computed tomography.

Comparison of geometric means led to consideration of a standardised difference of 0.5 and a total sample size of 120 for 80% power, at a two sided significance level of 0.05. Ignoring skewness of data, we considered a sample size of 120 sufficient to detect, at the same power and significance level, a difference in mean length of hospital stay of 4.0 days, assuming a common standard deviation of 8.0 days. A retrospective power calculation for a 10% absolute difference in mortality, similar to our observations and based on the numbers studied, was only around 65%. We used SPSS for Windows (version 9.0) for all analyses.

Results

Overall, 120 patients were recruited, of whom 57 (48%) were randomised to early computed tomography and 63 (53%) to standard practice. Two patients were excluded because one required surgery on admission and one was randomised after undergoing other radiological tests. In total, 118 patients completed our study (55 early computed tomography, 63 standard practice). The table presents the final diagnoses at 6 month follow up.

Hospital stay was 1.1 days shorter in the computed tomography arm than in the standard practice arm

Final diagnosis in patients undergoing randomisation. Values are numbers of patients (numbers who underwent surgery)

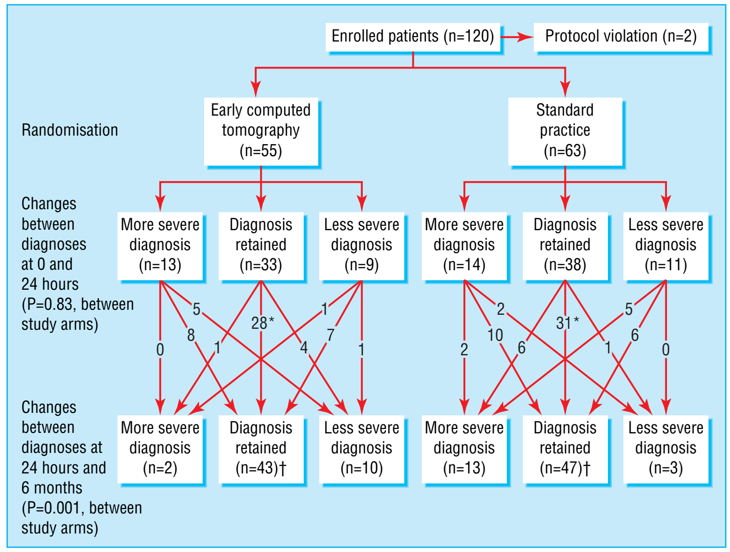
Final diagnosis	Early computed tomography (n=55)	Standard practice (n=63)
Diverticulitis	10	12
Appendicitis	7 (6)	4 (3)
Biliary colic or cholecystitis	4 (1)	7 (4)
Bowel obstruction	5 (1)	4
Acute pancreatitis	4	4
Malignancy	2 (1)	6 (1)*
Perforated viscus	1	5 (3)†
Peptic ulcer disease	2	4
Gastroenteritis	1	2
Intra-abdominal collection	1	1
Gynaecological abnormality	1	1
Renal colic	1	1
Ruptured abdominal aortic aneurysm	0	1 (1)‡
Irritable bowel disease	1	0
Intrathoracic disease	2	2‡
Other	3	1
Non-specific abdominal pain§	10	8 (1)

*Two patients died during admission.
†Three patients died.
‡One patient died.
§No cause for pain found.

(geometric mean 5.3 (range 1 to 31) days *v* 6.4 (1 to 60) days, respectively), but the difference was non-significant (95% confidence interval − 0.034 to 0.194; P=0.17). This corresponded to patients in the standard practice arm staying 20% longer than those in the early computed tomography arm (95% confidence interval 8% shorter stay to 56% longer stay). Untransformed means (SDs) were 6.6 (5.8) days for the early computed tomography arm and 9.2 (9.8) days for the standard practice arm, both with a median length of stay of 5 days (P=0.20, Mann-Whitney U test).

The figure presents a summary of changes in diagnosis between the initial diagnoses and 24 hour diagnoses, and between the 24 hour and final diagnoses. Only 50% (59 of 118) of diagnoses on admission were correct at 6 month follow up: 51% (28 of 55) in the early computed tomography arm and 49% (31 of 64) in the standard practice arm. This improved to 76% (90 of 118) after 24 hours (78% (43 of 55) and 75% (47 of 63), respectively). Accuracy of diagnoses at 24 hours differed significantly between the two groups (figure). This difference was mainly due to significantly more serious diagnoses being missed in the standard practice arm than in the early computed tomography arm (21% (13 of 63) *v* 4% (2 of 55), P=0.006). A small contribution came from an increased tendency for computed tomography to overstate the seriousness of diagnoses (18% (10 of 55) early computed tomography *v* 5% (3 of 63) standard practice, P=0.04). Seven inpatients in the standard practice arm died during the study (0% (0 of 55) early computed tomography *v* 11% (7 of 63) standard practice, P=0.014).

Seven patients randomised to standard practice underwent off-study computed tomography within 24 hours of admission. This had the effect of moving five patients to a more severe diagnosis. The as treated analysis produced the same conclusions as the intention to treat analysis.



Flow of patients through trial. *Number of admitting diagnoses correct at follow up; †number of diagnoses at 24 hours correct at follow up

Discussion

Abdominopelvic computed tomography undertaken early in patients admitted with acute abdominal pain improves the accuracy of diagnosis, may reduce length of hospital stay, and may reduce mortality. The observed difference in geometric mean length of stay (1.1 days) was not significant and, due to skewness, was noticeably less than the untransformed mean difference (2.6 days).

Seven deaths occurred in the standard practice arm. In some, early computed tomography might have correctly identified the diagnosis. Three patients were later found to have bowel perforations (two in association with diverticulitis and one with appendicitis) and one patient to have a ruptured abdominal aortic aneurysm; on admission these patients had been thought to have uncomplicated acute diverticulitis. Two of the other deaths were associated with malignancy and one with myocardial infarction. Caution is needed in generalising our results as mortality was not an a priori end point of our study.

Accurate diagnosis in patients with acute abdominal pain is fraught with difficulty—only half of the initial diagnoses in our population were correct at 6 month follow up. This poor accuracy is similar to that reported by other (uncontrolled) studies of similar patient groups (range 47-76%).[12–14] In these studies accuracy of diagnosis after computed tomography improved to 90-95%. We were neither able to reproduce such accuracy nor to show that early computed tomography was significantly better than standard practice for overall accuracy of diagnosis at 24 hours (around 75% in both arms). Early computed tomography did, however, identify significantly more of the serious diagnoses than standard practice, and it was probably this aspect that affected mortality.

Computed tomography is more sensitive and accurate at detecting abnormalities than plain radiography because of its cross sectional nature. The superiority of computed tomography in detecting free intraperitoneal gas is a good example.[15] The disadvantages of computed tomography include availability of resources and radiation dose.[16–22] The radiation dose for abdominopelvic computed tomography is 5-10 mSv (equivalent to around 2.3-4.5 years of natural background radiation, although with modern multidetector systems this may be less) compared with plain radiography of the chest and abdomen, which are typically 0.02-1.0 mSv. Computed tomography should therefore be used with caution in acute abdominal pain; it is probably best reserved for patients with pain of unknown cause. Computed tomography is not infallible and clinical evaluation and review remain crucial.[13 14 23]

We attempted to control for the effects of time by having patients re-evaluated 24 hours after admission, as change in symptoms and signs can be an important adjunct in diagnosis. This was arguably both a strength and a weakness. One weakness was the possibility for confounding factors—seven patients receiving early computed tomography underwent other radiological investigations and 13 patients receiving standard practice underwent off-study or delayed computed tomography. No differences emerged in the results between the intention to treat and as treated analyses. Limiting the study to weekends may have influenced referral patterns, timeliness of investigations, and clinical decision making.

What is already known on this topic

Computed tomography improves the accuracy of diagnosis of several acute abdominal conditions

Uncontrolled studies have shown improvements in accuracy of diagnosis after computed tomography; none have described an effect on mortality

What this study adds

Early abdominopelvic computed tomography for acute abdominal pain can identify unforeseen serious abdominal conditions

It may also reduce length of hospital stay and might reduce inpatient mortality

Standard practice varies between hospitals and countries. Nevertheless, we explored the widely different diagnostic approaches, exemplified by the United States and United Kingdom, to a common surgical problem. Early computed tomography enables appropriate identification of potentially serious surgical conditions, may reduce length of hospital stay, and might reduce mortality. The most likely reason for the non-significance of the results of our main outcome measures is that our study was underpowered, being based on a difference in length of hospital stay of 1.5 days.

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Contributors: CSN, CJEW, CRP, JAB, and AKD conceived and designed the study, analysed and interpreted the data, and drafted and revised the manuscript. TCS helped to interpret the data. NAB helped in the design of the study and analysis and interpretation of the data. BAH helped in the conception and design of the study. CSN will act as guarantor for the paper.

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