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Review

Low vs. standard dose computed tomography in suspected acute appendicitis: Is it time for a change?☆

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HIGHLIGHTS

- Clinical diagnosis is accurate in 80% of patients with suspected appendicitis with negative appendectomy rates of up to 21%.
- In the UK the use of standard-dose CT (SDCT) is conservative due to concerns over radiation exposure and cost.
- The use of low dose computer tomography (LDCT) instead of SDCT may partially address these concerns.
- This review illustrates that LD CT is not inferior to SD CT in the diagnosis of acute appendicitis.

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ABSTRACT

Background: Clinical diagnosis is accurate in only 80% of patients with suspected appendicitis with negative appendectomy rates of up to 21%. In the UK the use of standard-dose CT (SDCT) is conservative due to concerns over radiation exposure and resource implications. The use of low dose computer tomography (LDCT) instead of standard dose computer tomography (SDCT) may partially address these concerns.
Aim: To compare LDCT and SDCT in the diagnosis of appendicitis.
Methods: A literature search of the EMBASE and MEDLINE databases in July 2015 was conducted using the keywords 'low dose CT' and 'appendicitis'. Data were analysed and p values calculated using the Chi-square test. P values less than 0.05 were considered to be significant.
Results: LDCT (1.2–5.3 mSv) was not inferior to SDCT (5.2–10.2 mSv) in the diagnosis of acute appendicitis and proposing alternative diagnoses. SDCT was superior to LDCT in the negative predictive value of diagnosis of appendiceal perforation. There was no significant difference between LDCT and SDCT in negative appendectomy rate, appendiceal perforation rate and the need for additional imaging.
Conclusion: LDCT is not inferior to SDCT in the diagnosis of acute appendicitis and proposing alternative diagnoses. Further studies are recommended to further assess the potential role of LDCT & its cost effectiveness. Its use may improve the current management of patients with suspected acute appendicitis.

1. Introduction

Acute appendicitis is one of the most common causes of abdominal pain requiring surgery. Although it is frequently diagnosed clinically alone or with the aid of ultrasonography (US) and/or computer tomography (CT), there is no standardised approach for identifying patients with this condition, resulting in varying practice between medical centres [2]. Frequently patients require admission for close observation, serial blood tests and occasionally laparoscopy. This entails additional cost and variable morbidity. Moreover, many studies still report that clinical diagnosis is accurate in only 80% of patients [1] with negative appendectomy rates of up to 21%. In the UK the use of standard-dose CT is restricted due to concerns regarding radiation exposure and resource implications [3].

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While US can be used as first line imaging for acute appendicitis due to its high specificity, its value is limited due to the high rate of false negative or indeterminate results(4). This has led to the increased use of CT which has been associated with a reduction in both the rate of negative appendectomies and appendiceal perforations. These two outcomes are the reciprocal of false positive and delayed diagnosis respectively, which are important measures of quality of care [5]. While CT is considered to be a vital diagnostic tool for triaging patients with acute abdominal pain, there are concerns with regards to the radiation dose delivered to adolescents and young adults, a major component of the patient demographic of acute appendicitis, resulting in a possibly increased lifetime risk of cancer [6].

Many studies have suggested that the use of low dose computer tomography (LDCT) instead of standard dose computer tomography (SDCT) may be the solution to this dilemma. However, LDCT has a variety of limitations depending on the method of radiation exposure reduction e.g. scans limited to the lower abdomen can miss other important abnormalities outwith the scanned volume while the reduction of radiation dose decreases the image signal to noise ratio (SNR), potentially compromising diagnostic performance [7].

The primary aims of this systematic review are to compare LDCT and SDCT in the diagnosis of appendicitis, the diagnosis of appendiceal perforation and proposition of alternative diagnoses. The secondary aims are to compare LDCT and SDCT in negative appendectomy rates, appendiceal perforation rates and the need for additional imaging tests.

2. Method

2.1. Search strategy and inclusion and exclusion of articles

The exclusion criteria for the selection of articles were: non-human articles, non-English articles, articles containing paediatric patients (patients under the age of 15 years old), and articles containing pregnant women.

The search was performed in July 2015 using EMBASE, MEDLINE and PubMed with the search terms ‘low dose CT’ and ‘appendicitis’ resulting in the identification of 26 articles, of which 14 were initially excluded: four were not in relation to humans, four were not in English and finally six were not related to the patient demographic ‘adult 19 + years’. This resulted in a total of 12 articles that were screened by 2 authors (NEA & EHA). Of the 12 articles, none were found to be duplicates but a further seven were excluded: one that reviewed different imaging techniques for the diagnosis of appendicitis [8], one provided guidelines for imaging use during pregnancy and lactation [9], two evaluated the visualisation of the normal appendix [10,11] and one evaluated appendicitis in paediatric patients [12]. A further two articles were excluded following full text reading, one compared LDCT with US only and included paediatric patients [13] while the other was an evaluation of a diagnostic algorithm(2). A total of five articles were used in this systematic review([4–7], [14]) (Fig. 1).

A summary of articles and patient inclusion criteria for each article is found in Table 1. The publication dates of the articles used ranged from 2004 to 2012 with no overlap in study period, with the exception of one study that did not mention the study period within the article [4]. The total number of patients from all articles is 1536, however in three of the studies [4,7,14] the patient population received both LDCT and SDCT. As such, further subgroup analyses was required in order to reduce heterogeneity in the data used.

3. Definitions

The following definitions were used when analysing the results. *True Positive:* The test showed that the condition is present and the condition is actually present. *False Positive:* The test showed that the condition is present while the condition is not actually present. *True Negative:* The test showed that the condition is not present and the condition is not present. *False Negative:* The test showed that the condition is not present while the condition is actually present.

Sensitivity: how accurate the test is in correctly diagnosing the presence of a condition. *Specificity:* how accurate the test is in correctly diagnosing the absence of a condition. *Positive Predictive Value:* chance that the patient has the condition given a positive test. *Negative Predictive Value:* chance that the patient does not have the condition given a negative test.

3.1. Statistical analysis

P values were calculated using the Chi-square test. P values less than 0.05 was considered to be significant.

4. Results

4.1. Quality of included studies

The available published data comparing LDCT vs SDCT comprised CRT, non-randomized case-comparison series and case series. These studies were subject to significant bias, in terms of both the selection criteria for trial participants and also the reporting of the data. During critical appraisal of the literature, it became apparent that there was heterogeneity in the data reported by different studies.

4.2. Patient demographics

The patient demographics and the number of patients undergoing CT with each type of scanner are summarised in Table 2. While ideally the body mass index (BMI) of patients would be separated into further subgroups, there was no standardisation across the studies in reporting. Patients with a BMI <18.5 were considered to be slim while patients with a BMI ≥ 18.5 were considered to be non-slim.

4.3. Technical imaging parameters

Summary of the technical parameters is shown in Table 3. In three of the studies [5–7] the scan range was described as from the diaphragm to the symphysis pubis, in one, from the lung bases to the symphysis pubis [4] and in the last [14] from the liver to the symphysis pubis.

The reference tube-current-time product varied depending on the scanner used and the patient's body size. For LDCT it ranged from 25 to 130 mA while for SDCT it ranged from 80 to 240 mA.

The effective dose also varied and for some studies male and female patients received different effective doses. For LDCT the effective dose ranged from 1.2 to 5.3 mSv while for SDCT it ranged from 5.2 to 10.2 mSv.

Reconstruction slice thickness of the images ranged from 2 to 5 mm. Thinner slices were viewed as needed if the radiologists were not totally confident of the diagnosis when viewing the thick transverse sections.

Two studies(5,6) used intravenous (IV) contrast media for LDCT scans, one(4) used oral contrast media and two studies(7,14) opted for unenhanced imaging. For SDCT, all scans were enhanced with IV contrast media except one(14).