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Original Article

An audit of referrals for acute abdominal CT scans

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ABSTRACT

INTRODUCTION. The number of CTs performed worldwide has increased significantly over the past 20 years, with abdominal CTs being the most common. This trend has raised concerns about patient safety due to lifetime cumulative exposure to cancer-associated ionising radiation. The aim of this study was to evaluate the clinical justification for performing acute abdominal CTs in Danish patients admitted to a surgical department.

METHODS. This quality assurance study was conducted as a clinical audit at the North Denmark Regional Hospital. A total of 200 patients who had undergone acute abdominal CTs during a four-year period were randomly selected for review. Two independent audit teams, comprising radiologists and surgeons, assessed clinical justification through a consensus review of medical records.

RESULTS. The audit revealed that 36% of the acute abdominal CTs were deemed clinically unjustified. Two-thirds of these CTs were performed for an established or suspected malignancy.

CONCLUSIONS. One-third of the acute abdominal CTs were considered unjustified, primarily due to inconsistent or inadequate adherence to regional and national guidelines. Improved physician education and clearer diagnostic imaging guidelines for conditions with diagnostic uncertainty are recommended.

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CTs have become increasingly common over the past 20 years [1]. From 2012 to 2021, the annual number of CTs in Denmark increased from approximately 700,000 to 1.2 million [2]. Abdominal CTs, in particular, have followed this increasing trend, representing approximately 40% of all CTs performed annually in Denmark [3]. Abdominal CT is often used as a crucial diagnostic tool in the evaluation of patients presenting with acute abdominal pain, and this patient group constitutes 5-10% of all admissions to emergency departments [4, 5].

Ionising radiation from CTs is a well-documented human carcinogen [6]. However, the exact carcinogenic risk associated with ionising imaging methods remains a subject of ongoing debate. A small but statistically significant increase in the risk of several types of radiation-induced cancers has been reported [1]. The radiation dose from a CT varies depending on the specific type of scan, with an abdominal CT delivering an average effective dose of 10 mSv compared with the average annual background radiation of 3 mSv [1, 7]. Thus, one abdominal CT corresponds to approximately three years of natural background radiation [8]. In the United

States, it was estimated in 2005 that 1.5-2% of all registered cancers were attributable to ionising radiation from CTs [9]. Cancers associated with medical radiation exposure typically develop at least five years after exposure, and more frequently within one to two decades [8]. Non-ionising diagnostic imaging modalities, such as ultrasound and magnetic resonance imaging, should be preferred when clinically appropriate, as they reduce the cumulative lifetime risk of CT-induced cancer.

The increased use of CTs and their association with radiation-induced cancer raise important patient safety concerns [10]. The potential benefits of any diagnostic procedure, including CT, must always outweigh the associated risks [10, 11]. Considering both patient safety and health economics, it is therefore relevant to investigate whether all CTs performed are clinically justified.

The aim of this study was to assess the level of clinical justification for performing acute abdominal CTs in Danish patients.

Methods

Study design

This study was conducted as a clinical audit of Danish patients who underwent acute abdominal CTs during admission to the Department of Surgery at the North Denmark Regional Hospital from January 2018 to February 2022.

Study data

CT data were retrieved by the Business Intelligence Unit of the North Denmark Region, using Danish Health Care Classification System (SKS) codes for three scan types: upper abdomen (UXCD10), lower abdomen and pelvis (UXCD15) and total abdomen (UXCD00). All included scans were contrast-enhanced and classified as acute. These three codes collectively defined an “acute abdominal CT”.

Study population

Two cohorts of 100 patients each were randomly selected from two different periods: January-March 2018 and December 2021-February 2022. Randomisation was performed using Stata statistical software. Patient medical records were reviewed, and data were entered into the REDCap system [12], including information on age, gender, prior and current abdominal history, vital signs, biochemical parameters, radiological findings and surgical interventions. CT indications were categorised based on regional guidelines. A separate category, “Other,” was used to capture clinical indications that did not fit any predefined categories. Indications occurring five times or more were subsequently described in greater detail in the text accompanying the table.

Notably, a single referral for an acute abdominal CT could be associated with multiple clinical indications for the scan.

Data quality control

Three trained medical students entered the data into REDCap under the supervision of consultants in abdominal surgery and radiology. To ensure data validity, a three-step quality control process was implemented: step 1) an initial 10% sample of medical records was double reviewed with the consultants to establish consensus before proceeding with further data entry, step 2) a second 10% sample of completed REDCap records was reviewed to check for consistency with the source medical records, and step 3) a final review of all REDCap entries was conducted to ensure completeness of all data fields. This process ensured a high inter-observer and intra-observer reliability, and no further quality control measures were deemed necessary.

Clinical audit process

The clinical audit was conducted by two independent teams: Team 1 (a consultant radiologist and a radiology resident) and Team 2 (a consultant abdominal surgeon and a surgical resident). Each team independently reviewed the CT indications documented in the REDCap records, adopting a consensus-based approach.

The audit followed best practices in radiology and abdominal surgery, in line with regional guidelines for acute abdominal imaging. When guidelines were unavailable, justification was determined by clinical judgment. A CT was deemed justified if the expected diagnostic benefit outweighed the associated radiation risk and if the indication aligned with guidelines. Scans were considered unjustified if the risks outweighed the benefits and alternative modalities (e.g., ultrasound) were available, or the scan, though potentially indicated, should have been performed electively rather than acutely. The regional guidelines included recommendations for imaging in cases of suspected acute appendicitis, cholecystitis, diverticulitis and acute high-risk abdominal (AHA) conditions (e.g., ileus, perforation, ischaemia, anastomotic leak, bowel resection and intra-abdominal bleeding) [13].

Ethical considerations and data protection

This study was registered as a quality assurance project in accordance with Danish national research guidelines. Access to patient records was approved by hospital management and conducted in compliance with the General Data Protection Regulation (GDPR), Article 30. Therefore, written informed consent from patients was not required.

Statistical analysis

Data were analysed using IBM SPSS Statistics [14]. Descriptive statistics were used to summarise demographic and clinical characteristics. Results are presented as percentages and medians. Group comparisons between the two audit periods were performed using the χ^2- or Fisher's exact test, as appropriate. $p < 0.05$ was considered statistically significant.

Trial registration: not relevant.

Results

A total of 8,244 acute abdominal CTs were performed on 6,686 patients during the four-year reference period. No clinically relevant differences were found between the two audited patient subgroups from 2018 and 2022; the cohorts were therefore pooled for further analysis.

The combined audit cohort included 200 patients with a median age of 67 years. Among these, 56.0% were women and 44.0% were men (**Table 1**).

TABLE 1 Demographic and clinical characteristics in the audited patient population (N = 200).

Gender, n (%)	
Female	112 (56)
Male	88 (44)
Age, median, yrs	67
Indication for referral for acute abdominal CT, n (%)	
Malignancy	59 (29.5)
Infection without known focus	40 (20)
Abscess	26 (13)
Appendicitis	20 (10)
Diverticulitis	18 (9)
Ileus	25 (12.5)
Post-operative complication	18 (9)
Cholecystitis	9 (4.5)
Pancreatitis	9 (4.5)
Perforated hollow organ	6 (3)
Intestinal ischaemia	5 (2.5)
Other[a]	110 (55)

a) Registered justifications for acute abdominal CTs with > 5 counts; acute/prolonged pain (n = 16), hernia (n = 11), pneumonia (n = 7), control (n = 6), thrombosis/embolism (n = 5).

Clinical audit findings

The audit teams reached a consensus that 72 of the 200 acute abdominal CTs (36.0%) were clinically unjustified. The majority of these unjustified scans (49 CT scans, 68.1%) were performed in cases with either an established or suspected malignancy. By contrast, only 12 of the 72 unjustified scans (16.7%) were associated with other clinical conditions such as infection, abscess, diverticulitis, ileus or postoperative complications (**Table 2**).

TABLE 2 Distribution of clinical justification (yes vs no) of acute abdominal CT in accordance with the indication for CT referral.

	Clinical justification, n (%)			
Indication for CT	**yes**	**no**	**total**	**p value**
Malignancy	10 (16.9)	49 (83.1)	59	< 0.001
Infection	33 (82.5)	7 (17.5)	40	< 0.01
Abscess	23 (88.5)	3 (11.5)	26	< 0.01
Appendicitis	16 (80)	4 (20)	20	0.14
Diverticulitis	16 (88.9)	2 (11.1)	18	0.02
Ileus	25 (100)	0	25	< 0.001
Post-operative complication	18 (100)	0	18	< 0.001
Cholecystitis	6 (66.7)	3 (33.3)	9	1
Pancreatitis	4 (44.4)	5 (55.6)	9	0.29
Perforated hollow organ	6 (100)	0	6	< 0.001
Intestinal ischaemia	5 (100)	0	5	< 0.001
Other[a]	71 (64.6)	39 (35.4)	110	0.86

a) Registered justifications for acute abdominal CT with > 5 counts; acute/prolonged pain (n = 16), hernia (n = 11), pneumonia (n = 7), control (n = 6), thrombosis/embolism (n = 5).

Discussion

This clinical audit of acute abdominal CTs performed at the Department of Surgery, North Denmark Regional Hospital, revealed that one-third of the scans were classified as clinically unjustified according to current regional guidelines. These findings are consistent with previous European studies, which have reported that 20-39% of CTs were considered unjustified [11, 15-17]. This reflects a potential patient safety issue due to unnecessary exposure to ionising radiation, an issue of growing concern as CT utilisation continues to rise in Denmark and globally [1, 2].

The median age of the audit cohort was 67 years, which is particularly concerning given that the risk of radiation-induced malignancies increases with cumulative exposure and typically manifests 5-20 years after exposure [8]. A lack of awareness or underestimation among clinicians of this delayed risk, especially with repeated CT imaging, may contribute to the overuse of abdominal CTs in clinical practice [4, 5].

Foley et al. have reported that several European countries, including Denmark, lack comprehensive national guidelines for CT justification [11]. In Denmark, healthcare is regionally governed, leading to variability in clinical practice. The North Denmark Region has issued regional guidelines that include imaging recommendations for certain acute abdominal conditions. However, broader guidance on when and how to refer for CT imaging, particularly for malignancy or non-specific abdominal pain, is lacking [11]. This fragmented approach may partly explain the high rate of unjustified scans observed in this audit.

According to regional guidelines in the North Denmark Region, CT is recommended as first-line imaging for suspected AHA conditions and acute diverticulitis. For acute cholecystitis, ultrasound or magnetic resonance cholangiopancreatography is preferred, while acute appendicitis remains a clinical diagnosis, with imaging reserved for uncertain cases. CT is generally not indicated in classic cases of pancreatitis unless clinical or biochemical findings are atypical [13].

Our audit results showed good adherence to guidelines for AHA and diverticulitis. However, conditions such as appendicitis, cholecystitis and pancreatitis were distributed equally across justified and unjustified categories, indicating either a lack of clear guidance or inconsistent adherence to existing recommendations. Furthermore, the broad "Other" category, encompassing non-specific indications, was not significantly associated with either justified or unjustified scans, again pointing to ambiguity in clinical decision-making due to insufficient guidance.

Notably, malignancy, either confirmed or suspected, was the most frequent clinical context for unjustified CTs, accounting for two-thirds of such cases. Many referrals cited malignancy as the reason for acute CTs during hospital admission, despite Danish cancer pathway guidelines recommending elective outpatient imaging after discharge [18]. As such, these scans were deemed unjustified, not because the imaging was inappropriate per se, but because of inappropriate prioritisation. If conducted electively, in accordance with national cancer pathways, they would likely have been classified as justified.

This highlights a key distinction. Misclassification may result not from poor clinical judgment but from deviation in timing or protocol. This underscores the need for clearer, more detailed regional guidelines and better clinician education to align imaging practices with national recommendations.

A study by Vom et al. in Australia showed that the use of referral guidelines significantly reduced the rate of unjustified imaging. They also recommended providing feedback to referring physicians when scans were deemed unjustified to prevent future unnecessary exposures [19]. Similarly, Bouëtté et al. emphasised that even well-designed guidelines require active implementation and clinician engagement to achieve meaningful improvements in imaging justification [15]. Additionally, Lehtimäki et al. demonstrated that selective use of abdominal CT, rather than routine scanning, led to reduced hospital stays and healthcare costs [5]. These findings suggest that improving justification practices can benefit not only patient safety but also healthcare system efficiency.

To reduce inappropriate CT usage, we recommend implementing regular physician education focused on radiation risks and diagnostic imaging strategies. Furthermore, expanding or clarifying guidelines for conditions with high diagnostic uncertainty, such as pancreatitis and vague abdominal symptoms, could support better clinical decision-making. Such guidelines should specify whether imaging should be performed acutely, electively or substituted by non-ionising modalities.

Another approach could be implantation of artificial intelligence (AI) based interventions and clinical decision support to enhance accuracy and efficiency. The study by Khalifa et al. found increases in both effectiveness and accuracy and showed reduced costs when AI was implemented in the diagnostic process. However, implementation of guidelines and physician education is still needed [20].

This study has several limitations. The sample size was relatively small, and the audit teams were not blinded to patient groups or to each other, which may have introduced bias. Although we attempted to minimise this by alternating the review order between the teams, future studies should consider full blinding to further reduce potential bias. Strengths include the rigorous quality-control process for data collection and the auditors' expertise in radiology and abdominal surgery. These measures enhanced the reliability and credibility of the audit findings.

Conclusions

This clinical audit showed that one-third of acute abdominal CTs were considered unjustified, primarily due to inconsistent adherence to regional or national guidelines. These findings align with similar European audits and highlight the need to improve clinical decision-making in diagnostic imaging. Enhancing physician education, refining referral guidelines - particularly for conditions marked by diagnostic uncertainty - and promoting selective use of CT can reduce unnecessary radiation exposure, improve patient safety and optimise healthcare resource use.

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