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A prospective agreement study

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Ultra-low dose computed tomography of the chest in an emergency setting

A prospective agreement study

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Abstract

Ultra-low dose computed tomography (ULD-CT) assessed by non-radiologists in a medical Emergency Department (ED) has not been examined in previous studies. To (i) investigate intragroup agreement among attending physicians caring for ED patients (i.e., radiologists, senior- and junior clinicians) and medical students for the detection of acute lung conditions on ULD-CT and supine chest X-ray (sCXR), and (ii) evaluate the accuracy of interpretation compared to the reference standard. In this prospective study, non-traumatic patients presenting to the ED, who received an sCXR were included. Between February and July 2019, 91 patients who underwent 93 consecutive examinations were enrolled. Subsequently, a ULD-CT and non-contrast CT were performed. The ULD-CT and sCXR were assessed by 3 radiologists, 3 senior clinicians, 3 junior clinicians, and 3 medical students for pneumonia, pneumothorax, pleural effusion, and pulmonary edema. The non-contrast CT, assessed by a chest radiologist, was used as the reference standard. The results of the assessments were compared within each group (intragroup agreement) and with the reference standard (accuracy) using kappa statistics. Accuracy and intragroup agreement improved for pneumothorax on ULD-CT compared with the sCXR for all groups. Accuracy and intragroup agreement improved for pneumonia on ULD-CT when assessed by radiologists and for pleural effusion when assessed by medical students. In patients with acute lung conditions ULD-CT offers improvement in the detection of pneumonia by radiologists and the detection of pneumothorax by radiologists as well as non-radiologists compared to sCXR. Therefore, ULD-CT may be considered as an alternative first-line imaging modality to sCXR for non-traumatic patients who present to EDs.

Abbreviations: CT = computed tomography, CXR = chest X-ray, DLP = dose length product, ED = Emergency Department, mSV = millisievert, NCCT = non-contrast computed tomography, PACS = Picture Archiving and Communication System, sCXR = supine CXR, ULD-CT = ultra-low dose computed tomography.

Keywords: accuracy, chest X-ray, Emergency Department, low-dose CT, ultra-low dose CT

1. Introduction

Non-traumatic patients who present to Emergency Departments (ED) with acute respiratory symptoms are typically referred to a chest x-ray (CXR). CXR detects the most common diseases seen in these acute patients.[1]. However, CXR misses a significant proportion of lesions in patients presenting to an ED with decompensated heart failure, pneumonia, or pneumothorax.[2–7] The CXR can only be performed in a supine position for the most critically ill patients, which significantly lowers the diagnostic accuracy.[8,9]

The first-line imaging modality used in the ED needs to be accurate and patient-safe, especially in cases where the examination can only be done with the patient in a supine position.

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The authors have no conflicts of interest to disclose.

The data that support the findings of this study are available from a third party, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are available from the authors upon reasonable request and with permission of the third party: Region of Southern Denmark

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Improving the accuracy will better serve patients and reduce the costs of patient care. Computed tomography (CT) of the chest has better diagnostic accuracy than CXR. However, CT exposes the patient to more radiation, which increases the risk of radiation-induced cancer.[10]

Several countries have guidelines stating that a treatment plan for non-traumatic patients should be initiated within 4 hours of admission to an ED.[11–13] Receiving an assessment of a CXR from a radiologist in an ED may take longer than 4 hours. Therefore, the initial evaluation of the CXR is often performed by the ED clinician.

An alternative imaging modality for the ED should have a low radiation exposure to the patient as well as be able to aid clinicians and radiologists in initiating an effective treatment plan. One possible approach is using an ultra-low-dose CT (ULD-CT) of the chest which offers a lower radiation dose to the patient, even lower than a low-dose CT. The topic of ULD-CT and low-dose CT has received growing interest in recent years.[14] Although there is no universally accepted definition of "low-dose" CT, it is generally accepted that the radiation dose should be under 2.5 millisievert (mSv).

Studies assessing consolidation[15,16] and pleural effusions[17,18] on a chest ULD-CT with radiation doses lower than 0.35 mSv have shown that ULD-CT is an acceptable modality compared to standard dose CT when assessed by radiologists. Furthermore, in a study among radiologists authors found ULD-CT to have better or comparable diagnostic accuracy to an sCXR, indicating that ULD-CT may be a viable substitute for an sCXR in an emergency setting.[19] However, since the initial evaluation of sCXR in an ED is often assessed by clinicians (i.e., non-radiologists), it is important to study how the accuracy of ULD-CT compares to sCXR when assessed by non-radiologists. Additionally, it is important to ensure consistency of assessments between two or more reviewers when evaluating the validity of an imaging modality – in this case, a ULD-CT. Consistency is important whether the images are assessed by radiologists or clinicians (i.e., non-radiologists).

The purpose of this study was to (i) investigate the intragroup agreement on detection of acute lung conditions at ultra-low dose CT and supine CXR (sCXR) among attending physicians caring for ED patients (i.e., radiologists, senior- and junior clinicians) and medical students, and ii) evaluate the accuracy of interpretation compared to the reference standard, non-contrast CT (NCCT).

2. Materials and Methods

Data from this patient population (i.e., patient characteristics, ULD-CT images, and sCXR) has been used in a different article to evaluate the diagnostic accuracy of ULD-CT when assessed by radiologists by "Tække r et al." as well as the feasibility (time and resources used) of ULD-CT compared to sCXR in an ED.[19] The current article was conducted to validate said article by evaluating the accuracy and intragroup agreement of the same radiologists as well as expanding on the number of observers by including emergency physicians and medical students to reflect the clinical workflow in a typical ED.

The Region of Southern Denmark has legal rights and control over the data from this study. The data are not publicly available. Data are available from the authors upon reasonable request and with permission from the Region of Southern Denmark.

2.1. Ethics

The project was approved by the (Danish) Data Protection Agency (2012-58-0018) and the regional ethics board. The ethics board approved the recruitment of approximately 100 patients. Informed written consent was obtained from all participants. Participants were not included if study participation was thought to affect or delay treatment. Participants received no financial compensation.

Study participants received additional radiation of approximately 3.25 mSv (NCCT: 3.2 mSv + ULD-CT: 0.05 mSv) with an added risk for a fatal cancer of approximately 0.016%.[20] Participants <40 years were excluded from this study as they have a higher risk of developing fatal cancer due to the additional radiation. Participants could only be enrolled twice to avoid an accumulation of radiation.

2.2. Participants and recruitment

This single-center, prospective study was carried out in the ED's radiology section of (Odense University Hospital, Odense, Denmark). Participants were enrolled consecutively between February 1st and July 31st, 2019.

The inclusion criteria consisted of non-traumatic patients presenting to the ED who had an sCXR. Study participants consisted of patients with medical conditions. The exclusion criteria were ≥1 of the following:

(1) Informed written consent not obtained
(2) Patient <40 years
(3) Participation delayed life-saving treatment
(4) The interval between sCXR and ULD-CT surpassed 4 hours
(5) Participants enrolled more than twice in the study

2.3. Imaging modalities

The sCXR was performed by radiographers using the Siemens YSIO imaging system (Siemens Healthcare GmbH, Erlangen, Germany) according to department guidelines.

A specially designed technical ULD-CT protocol was created using a chest phantom (N1 "Lungman," KYOTO Kagaku, Japan) corresponding to an 80 kg male. Included participants were scanned in a GE Revolution CT (GE Healthcare, Waukesha, IL) with a 350 mm scan range and 128 × 0.625 mm detector. All participants were scanned in a supine position with their feet first. The scan parameters are listed in Table 1. The ULD-CT scans were performed with fixed tube current and no scout views. The NCCT was performed consecutively and chosen as the reference standard to avoid contrast infusion of the study participants. The CT scans were performed in addition to the patient's scheduled sCXR.

2.4. Data collection

Data on the participants' age, sex, weight, height, and body mass index were acquired through the patient medical records. In cases where weight, height, and body mass index were not available, the participants were asked, or estimations were made by CT staff.

The assessors were 3 radiologists (MLF, PWG, OG), 3 senior clinicians (JD, SP, CHR), 3 junior clinicians (LPB, KG, HS), and 3 medical students (BK, MT, MHB). Senior clinicians were specialists in emergency medicine and attended the ED along with junior clinicians. Junior clinicians were physicians not yet specialized within a specialty area of medicine. Clinicians had experience with evaluating CXRs and minimal experience evaluating CT scans. No assessor had experience with ULD-CT specifically. The medical students completed a course on basic radiology during medical school which consisted of training in the assessment of a CXR. Furthermore, assessors were instructed to use a radiology educational website[21,22] for CT image interpretation of the four lung conditions included in our study. Assessment of the NCCT was done by a chest radiologist who specialized in NCCT with 9 years of experience.

Assessors had access to PACS (Picture Archiving and Communication System) for assessment of the images between

Table 1

Scan acquisition parameters for non-contrast computed tomography (NCCT) and ultra-low dose computed tomography (ULD-CT) protocols.

Scan mode	NCCT	ULD-CT
Tube voltage (kVp)	100	80
Tube current (mA)	20–579; modulated	10
Bowtie filter	Body 32 cm	Body 32 cm
Image quality metric	Noise index 27	Not applicable
Pitch	0.992	0.992
Rotation time (s)	0.35	0.5
Field of view (mm)	350	350
Image reconstruction	30% ASiR-V*	100% ASiR-V*
Reconstruction algorithm	Lung	Lung
Contrast-enhanced	No	No

*Adaptive statistical iterative reconstruction.

June and August 2019. Assessments were performed consecutively starting with the images acquired in February 2019 and ending with the images acquired in July 2019. Assessors evaluated images acquired using each modality independently and were blinded to the participant's clinical data and previous radiology. ULD-CT images of all patients were assessed first before moving on to the sCXR images to prevent the assessment of two consecutive examinations of the same patient.

Assessors were asked whether the following conditions were present

- Pneumonia
- Pneumothorax
- Pleural effusion
- Cardiogenic pulmonary edema

A GE Centricity RA1000 PACS (GE Healthcare) workstation with diagnostic monitors was used for assessments of the ULD-CTs. ULD-CT images were reconstructed with 5 mm slice thickness and presented in sagittal, axial, and coronal planes in the lung window setting (window width: 1465HU, window level: -498HU). Assessors received a short introduction to PACS. Pilot examinations were performed in 14 examinations to allow assessors to familiarize themselves with PACS. Pilot examinations were not included in the study.

2.5. Statistical analysis

Study data were collected and managed using REDCap electronic data capture tools[23,24] hosted at (Odense University Hospital, Odense, Denmark). Data were analyzed with Stata 15.1 (Stata Corp, TX).

The interobserver agreement is often reported with the diagnostic accuracy as a measure of whether two or more independent observers measure the same event. However, a recent systematic review on the diagnostic accuracy of ULD-CT found that the method of reporting interobserver agreement differed between studies as some compare agreement between observers. Some compare it to the gold standard and others compare the agreement of different imaging modalities.[14] For conceptional clarity, we chose the wording "intragroup" agreement to describe the agreement between the three members of each group (i.e., radiologists, senior clinicians, junior clinicians, and medical students). However, perfect agreement within groups is meaningless if it is not compared with accuracy. Therefore, we chose to compare the observers' assessment with the gold standard, and NCCT assessed by a chest radiologist. The reporting of accuracy, as opposed to the diagnostic accuracy, was also done to avoid duplicate publications as previously mentioned.

Accuracy and intragroup agreement were measured using Cohen's and Fleiss' kappa, respectively. Grading was classified as <0: no agreement, 0–0.20: slight, 0.21–0.40: fair, 0.41–0.60: moderate, 0.61–0.80: substantial, and 0.81–1: almost perfect agreement.[25] Assessments of the ULD-CT and sCXR respectively were compared to the reference standard (NCCT).

The effective dose in mSv was calculated with the formula Effective Dose = DLP × k, where k is the chest specific conversion factor; k = 0.014 mSv/mGy cm.[26]

3. Results

The 93 included sCXR, ULD-CT, and NCCT examinations were performed on 91 non-traumatic participants. Two participants were included twice during two separate ED visits. A flowchart illustrating the inclusion of the participants examined for pneumonia, pneumothorax, pleural effusion, and cardiogenic pulmonary edema by ULD-CT and sCXR can be seen in Figure 1. In cases where the ULD-CT was not performed due to patient-related issues, or logistical- or technical issues, the data were excluded.

The interval between the sCXR and ULD-CT/NCCT was less than 1 hour for most (66%) of the examinations. For 16% of the examinations, the interval was between 1 and 2 hours, and for 12% of the examinations between 2 and 3 hours. Only 6% of the examinations had more than a 3-hour interval between them. According to our exclusion criteria, the interval between examinations could not succeed the 4-hour limit. No adverse events occurred from performing the index or reference tests.

Characteristics of the participants included in the study are shown in Table 2.

The mean effective dose was 0.05 ± 0.01 mSv (range 0.04–0.06) and 3.2 ± 1.6 mSv (range 1–7.4) for ULD-CT and NCCT respectively making the mean dose reduction for ULD-CT 98% when compared to NCCT. The ULD-CT had a lower CT dose index volume (0.11 vs 6.6 mGy) and DLP (3.8 vs 238 mGy*cm) than the NCCT. The dose for sCXR was approximately 0.1 mSv according to the local Radiology Department's standard practice.

Prevalence of the four acute lung conditions (i.e., pneumonia, pneumothorax, pleural effusion, and cardiogenic pulmonary edema) was low in all cases with the most prevalent being pleural effusion affecting around 30% of participants.

3.1. Intragroup agreement

The intragroup agreement (A: radiologists, B: senior clinicians, C: junior clinicians, and D: medical students) can be seen in Table 3. The main findings for the intragroup agreement were no (A: 0.00, B: −0.01, D: −0.03) or fair (C: 0.31) agreement for the assessment of pneumothorax using sCXR. Agreement for pneumothorax on ULD-CT was moderate to almost perfect (0.49–1.00). Furthermore, the agreement for pneumonia was moderate on sCXR (0.52) and substantial when using ULD-CT (0.72) for the radiologists (A). For the junior clinicians (C) the agreement on detection of pneumonia was fair on sCXR (0.21) and substantial when using ULD-CT (0.66). The agreement between the medical students (D) for pleural effusion was slight on sCXR (0.15) and fair when using ULD-CT (0.34).

3.2. Accuracy

Accuracy in the detection of pneumonia, pneumothorax, pleural effusion, and cardiogenic pulmonary edema by ULD-CT and sCXR are shown in Table 4. Accuracy was compared to the reference standard, an NCCT. The main findings for accuracy were no (−0.06 to 0.02) or slight (0.00) agreement when using sCXR for the assessment of pneumothorax (Fig. 2). When using ULD-CT the agreement was fair to substantial (0.39–0.66)

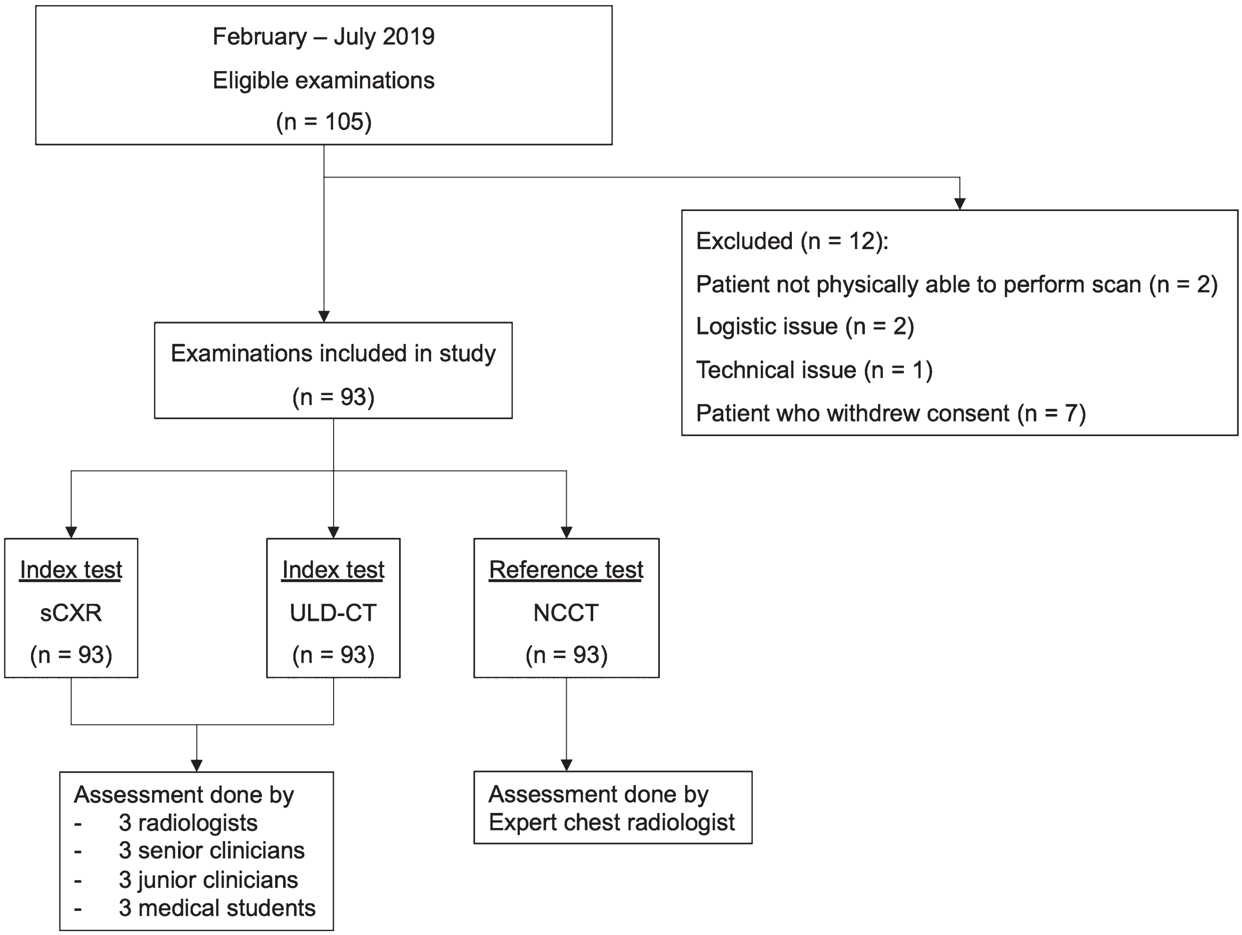

Figure 1. Flowchart of the participant inclusion process in a study of intragroup and interobserver agreement of ULD-CT and sCXR for patients in an Emergency Department. Abbreviations: sCXR = supine chest X-ray, ULD-CT = ultra-low dose computed tomography.

depending on the group. Furthermore, for the radiologists the kappa agreement was fair (0.24–0.40) for the detection of pneumonia on sCXR and moderate (0.42–0.58) when ULD-CT was used for assessment. The kappa agreement for the detection of pneumonia was slight on sCXR (0.07, 0.08) for two of the medical students. On ULD-CT the agreement was fair (0.20, 0.24) for the same two students. For the detection of pleural effusion, the kappa agreement was fair (D2: 0.31) or slight (D3: 0.07) for two of the medical students using sCXR and moderate (D2: 0.60) to fair (D3: 0.24) on ULD-CT.

Table 2

Patient characteristics in a study of accuracy and intragroup agreement of ultra-low dose CT and chest x-ray for four lung conditions.

Characteristics	Sex	N	Mean ± SD (range)
Age (y)		91	78 ± 10.6 (42–150;97)
	Women	48	78 ± 11.2 (42–150;97)
	Men	43	77 ± 9.9 (57–150;93)
Height (cm)		91	166 ± 10.8 (138–150;193)
	Women	48	160 ± 9.3 (138–150;184)
	Men	43	172 ± 8.3 (155–150;193)
Weight (kg)		91	72 ± 20.6 (39–150;139)
	Women	48	67 ± 20.8 (39–150;139)
	Men	43	77 ± 19.1 (51–150;130)
BMI (kg/m^2)		91	25.9 ± 6.6 (15.6–150;47.3)
	Women	48	25.9 ± 7.6 (15.6–150;47.3)
	Men	43	25.8 ± 5.4 (17.1–150;41.5)

4. Discussion

Previous studies[15,17,18,16,19] have suggested that an ultra-low dose chest CT (ULD-CT) is an acceptable alternative to standard-dose CT when assessed by radiologists for various patient populations. However, previous diagnostic studies on the use of ULD-CT have not examined whether ULD-CT can be used when assessed by non-radiologists in an ED. This study found that accuracy and intragroup agreement improved for pneumothorax on ULD-CT compared to sCXR for all groups (i.e., radiologists, non-radiologist physicians, and medical students). Improved accuracy and intragroup agreement on ULD-CT were also seen for pneumonia when assessed by the radiologists and for pleural effusion when assessed by the medical students.

Improved accuracy was not seen for other diagnoses than pneumothorax by the senior- or junior clinicians. A previous study on pneumonia found bedside ultrasound done by trained emergency clinicians to be more accurate than a blinded assessment of CXR by a radiologist.[27] Although the mentioned study uses a different imaging modality than the current study, it may suggest that the clinician's accuracy is highly dependent on the patient's clinical data. In the current study, the assessors did not receive any formal training in ULD-CT and were blinded to clinical information, a situation unfamiliar to most clinicians. Therefore, the accuracy of the clinicians might have been better

Table 3

Intragroup agreement (kappa) for ULD-CT and sCXR across physician- and medical student groups for four lung conditions.

	Pneumonia (10/93)		Pneumothorax (4/93)		Pleural effusion (29/93)		Cardiogenic pulmonary edema (9/93)	
Groups	ULD-CT	sCXR	ULD-CT	sCXR	ULD-CT	sCXR	ULD-CT	sCXR
A	0.72 (89)	0.52 (83)	0.80 (99)	0.00 (66)	0.76 (92)	0.69 (89)	0.09 (95)	0.08 (85)
B	0.33 (67)	0.38 (70)	0.75 (99)	-0.01 (97)	0.58 (86)	0.72 (89)	0.08 (91)	0.80 (86)
C	0.66 (84)	0.21 (61)	1.00 (100)	0.31 (96)	0.57 (86)	0.61 (85)	-0.04 (91)	0.50 (84)
D	0.30 (67)	0.22 (62)	0.49 (98)	-0.03 (61)	0.34 (79)	0.15 (63)	0.09 (96)	0.12 (80)

A: radiologists, B: senior clinicians, C: junior clinicians, D: medical students. Each group has 3 assessors. Values in parenthesis are percent agreement.
sCXR = supine chest X-ray, ULD-CT = ultra-low dose computed tomography.

Table 4

Accuracy (kappa) for ULD-CT and sCXR when compared to reference standard (NCCT) for four lung conditions.

	Pneumonia (10/93)		Pneumothorax (4/93)		Pleural effusion (29/93)		Cardiogenic pulmonary edema (9/93)	
Assessors	ULD-CT	sCXR	ULD-CT	sCXR	ULD-CT	sCXR	ULD-CT	sCXR
A1	0.51 (86)	0.24 (80)	0.39 (97)	0.00 (96)	0.56 (84)	0.64 (86)	0.59 (94)	0.38 (83)
A2	0.58 (88)	0.40 (86)	0.66 (98)	-0.02 (95)	0.73 (89)	0.63 (85)	0.00 (90)	0.00 (90)
A3	0.42 (80)	0.26 (72)	0.66 (98)	0.00 (96)	0.73 (89)	0.70 (88)	0.18 (91)	0.10 (88)
B1	0.17 (58)	0.17 (67)	0.66 (98)	0.00 (96)	0.57 (82)	0.57 (81)	0.45 (91)	0.42 (85)
B2	0.21 (63)	0.15 (59)	0.39 (97)	-0.04 (92)	0.56 (84)	0.57 (82)	0.18 (91)	0.35 (81)
B3	0.39 (77)	0.28 (71)	0.39 (97)	-0.02 (95)	0.56 (84)	0.64 (86)	0.18 (87)	0.24 (80)
C1	0.22 (61)	0.18 (59)	0.39 (97)	-0.03 (94)	0.50 (81)	0.45 (78)	0.00 (90)	0.18 (74)
C2	0.34 (76)	0.31 (78)	0.39 (97)	-0.05 (89)	0.57 (83)	0.64 (85)	0.12 (89)	0.20 (84)
C3	0.19 (65)	0.05 (42)	0.39 (97)	-0.02 (95)	0.56 (83)	0.65 (85)	0.14 (85)	0.23 (78)
D1	0.25 (71)	0.16 (57)	0.39 (97)	0.00 (96)	0.51 (78)	0.53 (77)	0.30 (91)	0.44 (89)
D2	0.20 (58)	0.07 (52)	0.39 (97)	0.00 (96)	0.60 (85)	0.31 (68)	0.15 (90)	0.31 (81)
D3	0.24 (76)	0.08 (75)	0.48 (96)	-0.06 (87)	0.24 (74)	0.07 (69)	0.34 (92)	-0.05 (87)

Assessors A1–A3: radiologists, B1–B3: senior clinicians, C1–C3: junior clinicians, and D1–D3: medical students. Values in parenthesis are percent agreement.NCCT = non-contrast computed tomography, sCXR = supine chest X-ray, ULD-CT = ultra-low dose computed tomography.

if they had training in the assessment of ULD-CT and access to clinical information. In this case, the results would have been more reflective of the clinicians' daily practice.

The level of intragroup kappa agreement for pneumothorax and pleural effusion in this study was slightly lower than what previous diagnostic studies have shown.[17,18] The prevalence of disease was lower in this study than in the above-mentioned studies[24,26] which might be explained by the difference in setting and the patients included. One study included trauma patients[18] and the other included patients who had undergone lung transplantation.[17] The current study consisted of a heterogeneous consecutive group of non-traumatic medical patients in the ED. Feinstein et al have shown that low kappa values in some cases can be ascribed to skewed marginal distributions.[28]. In other words, a low prevalence of disease can cause the kappa values to appear low even when the percent agreement is high. This paradox of high agreement and low kappa was seen in this study. The low kappa values found in this study compared to previous studies might therefore be explained by the low prevalence of pneumonia, pneumothorax, pleural effusion, and cardiogenic pulmonary edema.

The radiation dose in our study was to our knowledge the lowest value reported in diagnostic studies on ULD-CT of the chest. As stated in the result section the mean radiation dose from the ULD-CT in this study was 0.05 mSv which is lower than the department's guidelines of 0.1 mSv for an sCXR. Apart from the low prevalence of disease in our study population, the low radiation dose might explain the low agreement with the reference standard. It is advantageous for patient safety to have low radiation exposure. However, the accuracy may have improved in this study had the radiation dose been higher, around 0.1 mSv, without compromising patient safety. Future advances in CT will likely offer even better image quality with the radiation dose adjusted to the patient.

This study reported accuracy and intragroup agreement for other staff groups and in a different setting than previously reported in diagnostic studies on ULD-CT of the chest.[15,17,18,16] In the studies mentioned, the assessment was done by radiologists as the studies took place in a Radiology Department. This study included non-radiologist physicians to better reflect the workflow in an ED. The agreement of the non-radiologists found in this study can therefore not be compared to previous literature.

As this was a diagnostic study, we did not use follow-up of the patients. We can therefore not comment on the outcome for those patients whose pneumonia, pneumothorax, pleural effusion, or pulmonary edema was caught on ULD-CT compared to patients who only had an sCXR. However, there were several cases where the correct diagnosis could not be made from an sCXR but could be seen on the ULD-CT scan (e.g., in Fig. 2). Further studies are needed to compare the two modalities regarding the patient outcome, in-hospital duration, and treatment.

A limitation of this study was that assessors may have performed differently on the assessment compared to their daily practice as their performance had no clinical consequences.

The sample size in this study is in the higher end of diagnostic studies on the accuracy of ULD-CT of the chest. However, the broad inclusion criteria and the heterogeneous study population used in this study might require an even larger sample size.

This study is strengthened by a large number of assessors. Not only did each group consist of 3 assessors, but also non-radiologist physicians were included reflecting the workflow in an ED. Finally, this study gives insight into the use of ULD-CT as a first-line imaging modality in an ED consisting of a heterogeneous patient population that has not been previously explored by other diagnostic studies. Future studies on this subject should include a larger sample size and analysis should be specific to the clinical problem. Furthermore, future studies on this subject

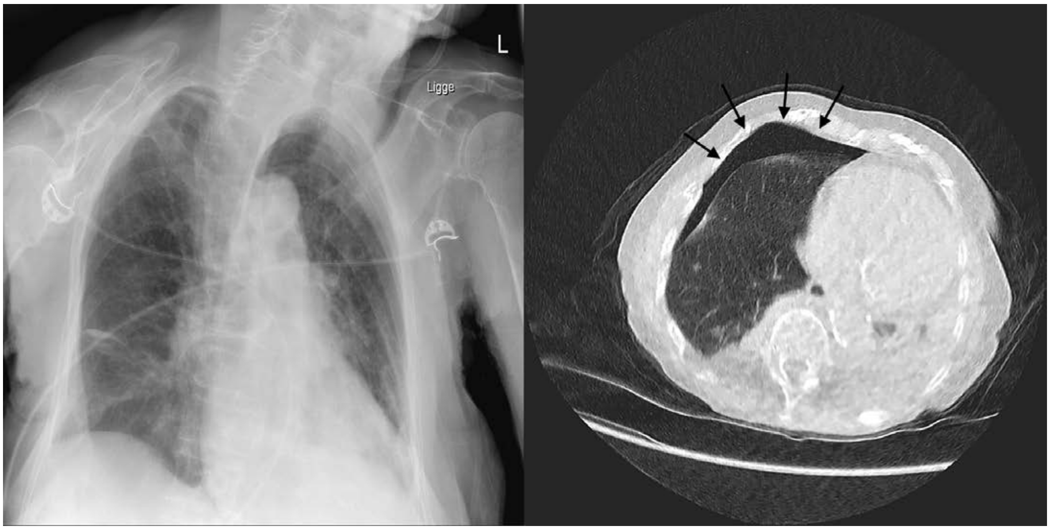

Figure 2. A supine chest X-ray (sCXR) and ultra-low dose computed tomography (ULD-CT) image without contrast in axial view. The images are of a 97-year-old woman with right-sided pneumothorax. No assessor reported the pneumothorax on the sCXR, but all assessors detected the pneumothorax on the ULD-CT.

involving clinicians should give organized training in the assessment of ULD-CT and include clinical information about the patient to reflect the daily practice of the clinician.

Although ULD-CT improves the detection of pneumonia and pneumothorax it requires more resources.[19] The feasibility of ULD-CT in an ED has been extensively reported by "Tækker et al."[19] as stated in the materials and method section. The study reported that the median staff time for a ULD-CT scan was 10 minutes compared to a 5-minute sCXR. Furthermore, the ULD-CT often required 1 more personnel to move the patient from the hospital bed to the CT scanner compared to the sCXR. The availability of the CT scanner of course must be taken into account when considering the feasibility of replacing sCXR for select patients. In our study population, several of the patients were scheduled for an sCXR as well as other imaging modalities like a CT-cerebrum. In those cases, adding a ULD-CT scan to the CT-cerebrum scan would presumably take less total staff time and personnel compared to taking the CT-cerebrum scan and sCXR subsequently. This was however not quantified further in this study. A full cost-benefit analysis comparing ULD-CT to sCXR should be done in future studies.

In conclusion, ULD-CT improves the detection of pneumonia by radiologists and the detection of pneumothorax by radiologists, senior- and junior clinicians, and medical students in non-traumatic patients with acute lung conditions when compared to a sCXR. ULD-CT may be considered as an alternative first-line imaging modality to supine CXR for non-traumatic patients presenting to the ED.

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