Diagnostic and Interventional Imaging (2019) **100**, 85—93

ORIGINAL ARTICLE / *Thoracic imaging*

Ultra-low-dose unenhanced chest CT: Prospective comparison of high kV/low mA versus low kV/high mA protocols

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KEYWORDS
Multidetector computed tomography;
Radiation dose;
Lung;
Comparative studies;
Quality assessment

Abstract
Purpose: To qualitatively and quantitatively compare unenhanced ultra-low-dose chest computed tomography (ULD-CT) acquired at 80 kVp and 135 kVp.
Materials and methods: Fifty-one patients referred for unenhanced chest CT were prospectively included. There were 29 men and 22 women, with a mean age of 64.7 ± 11.6 (SD) years (range: 35—91 years) and a mean body mass index of 26.2 ± 6.3 (SD) (range: 17—54.9). All patients underwent two different ULD-CT protocols (80 kVp-40 mA and 135 kVp-10 mA). Image quality of both ULD-CT examinations using a 5-level scale as well as assessability of 6 predetermined lung parenchyma lesions were blindly evaluated by three radiologists and compared using a logistic regression model. Image noise of the two protocols was compared with Wilcoxon signed-rank test.
Results: The mean dose-length product at 80 kVp and at 135 kVp were 14.7 ± 1.8 (SD) mGy.cm and 15.6 ± 1.9 (SD) mGy.cm, respectively ($P < 0.001$). Image noise was significantly lower at 135 kVp (58.9 ± 12.4) than at 80 kVp (74.7 ± 14.5) ($P < 0.001$). For all readers and for all examinations, the 135 kVp protocol yielded better image quality than 80 kVp protocol, with a mean qualitative score of 4.5 ± 0.7 versus 3.9 ± 0.8 ($P < 0.001$). The 135 kVp protocol was significantly more often of diagnostic quality than the 80 kvp protocol (92.3% versus 77.8%, respectively) ($P < 0.001$) and was less prone to image quality deterioration in obese patients. Parenchymal lesions were never better depicted on the 80 kVp protocol than with the 135 kVp protocol.
Conclusion: Unenhanced chest ULD-CT should be acquired at a high kilovoltage and low current, such as 135 kVp-10 mA, over a low kilovoltage and high current protocol.

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https://doi.org/10.1016/j.diii.2018.11.012

Abbreviations

AIDR	Adaptative iterative dose reduction
BMI	Body mass index
DLP	Dose-length product
HU	Hounsfield unit
IR	Iterative reconstruction
ROI	Region of interest
SDD-CT	Standard-dose diagnostic computed tomography
TTD	Transversal thoracic diameter
ULD-CT	Ultra-low-dose computed tomography

Introduction

Radiation dose reduction is a public health matter because of a growing use of computed tomography (CT) and the associated radiation exposure [1,2]. Many techniques have been developed to reduce the radiation dose [3,4]; one of the most effective being the iterative reconstruction [5,6], which allows a significant radiation dose reduction over the classical filtered back projection algorithm, while preserving image quality [7,8]. Thanks to these algorithms, chest CT can be obtained with a radiation dose similar to that of a double incidence chest X-ray in posterior-anterior and lateral views. Known as the ultra-low-dose chest CT (ULD-CT) technique, this type of acquisition can remain diagnostic even though the image quality is voluntarily deteriorated [9—11]. Studies have thus showed promising results regarding the implementation of ULD-CT in several clinical indications. In this regard, ULD-CT has been successfully used for the detection and follow-up of solid pulmonary nodules [12,13], detection of pleuropulmonary diseases after asbestos exposure [14], CT-guided lung biopsy [15], detection of infections in neutropenic patients [16] or post-surgical monitoring of lung cancer patients [17].

However, there is currently no reference acquisition protocol for unenhanced ULD-CT, and each manufacturer combines different image settings, varying the tube voltage and the current (Table 1). Two main different approaches were described in the literature being either a ''low voltage — high current protocol'', like 80 kVp-40 mA, or a ''high voltage — low current'' protocol like 135 kVp-10 mA [14,18—20]. But to date, no studies have compared these different protocols.

The primary endpoint of this work was to qualitatively and quantitatively compare non-unenhanced ultra-low-dose chest computed tomography (ULD-CT) acquired at 80 kVp with ULD-CT acquired at 135 kVp.

Materials and methods

This prospective study was approved by our institutional review board, and written informed consent was obtained from all patients.

Population

During three consecutive months, all in and outpatients referred for a clinically indicated unenhanced chest CT outside of an emergency context were approached for participation. The inclusion criterion was a minimum age over 35 years for men and 45 years for women, and the exclusion criteria were the inability to give informed consent, an out-of-control agitation and the incapacity to raise the arms above the head. Age, sex, body mass index (BMI) and maximum transversal thoracic diameter (TTD) measured on a transverse CT slice were recorded for each patient.

CT examination and data reconstruction

All CT examinations were acquired on a second-generation 320-row scanner (Aquilion ONE® Vision Edition, Toshiba). Each participant underwent a triple acquisition unenhanced chest CT: a ''standard-Dose'' (SDD-CT) acquisition (120 kV with automated tube current modulation) and two ULD-CT acquisitions (80 kVp-40 mA followed by 135 kVp-10 mA, without automatic tube current modulation). The SDD-CT acquisition was for diagnostic use only and its analysis was outside the scope of this study.

The two ULD-CT acquisitions were specifically added for this work, and their fixed current were chosen to achieve the same level of radiation dose between 135 kVp and 80 kVp (i.e., an identical computed tomography dose index [CTDIvol] and a target radiation dose of 0.2 mSv). The parameters of the ULD-CT acquisitions are described in Table 2. The field-of-view was kept identical for all acquisitions. Patients were positioned in the supine position with their arms raised above their heads and had to realize three successive apneas. All CT acquisitions were reconstructed with an iterative algorithm (adaptative iterative dose reduction using AIDR-3D, Toshiba) set in the ''standard'' level.

Table 1 Potential variation of ULD chest CT acquisition protocols among vendors.

Vendor	IR Algorithm	Acquisition parameters	Reference
Siemens	SAFIRE	80 kV-60 mA	[18]
General Electric	MBIR	120 kV-20 mA	[19]
Philips	IDOSE4	120 kV-13 mA	[20]
Toshiba/Canon	AIDR-3D	135 kV-10 mA	[14]

SAFIRE: Sinogram-AFfirmed Iterative REconstruction; MBIR: model-based iterative reconstruction; AIDR: adaptive iterative dose reduction.

Table 2 Acquisition parameters using two different ultra-low dose CT protocols.

	ULD-CT 80 vVp	ULD-CT 135 kVp
Tube peak kilovoltage	80 kV	135 kV
Tube current	40 mA	10 mA
Tube current-time product	12 mAs	3 mAs
Pitch	0.813	0.813
Tube rotation time	0.275 s	0.275 s
CTDIvol	0.40 mGy	0.40 mGy
Collimation	0.5 × 80	0.5 × 80
Slice thickness	0.5 mm	0.5 mm
Reconstruction of mediastinum volume	1 mm every 0.8 mm	1 mm every 0.8 mm
Reconstruction of lung parenchyma volume	0.5 mm every 0.3 mm	0.5 mm every 0.3 mm

CTDI: computed tomography dose index.

Data analysis

To enable blinded evaluation, each image dataset was anonymized and randomized. Lung and mediastinum reconstructions were kept together for the same patient. All ULD-CT examinations were independently and blindly assessed by three radiologists (MO with 7 years of experience in chest CT, AL with 5 years of experience and CL, radiology resident with 3 years of experience) on a dedicated workstation (Vitrea, Version 6.4, Vital Images) with systematic multiplanar and maximum intensity projection reconstructions. Images were displayed with lung (level −700 HU and width 1500 HU) and mediastinal (level 50 HU and width 350 HU) window setting; the contrast could be adapted by the reader. All the results were recorded in an anonymous spreadsheet (Excel 2010, Microsoft).

Radiation dose

Dose-length product (DLP) expressed in mGy.cm for each acquisition was recorded from the electronically stored patient protocol. Effective dose in mSv was estimated by multiplying the DLP by the chest-specific conversion coefficient (0.014 mSv/mGy.cm) [18,19].

Quantitative image analysis

Image noise was defined as the standard deviation (SD) of the air density measured within the tracheal lumen, just above the carina, on the lung parenchyma reconstructions (i.e. FC51 sharp kernel). A circular region of interest (ROI) of at least 20 mm^2 was delineated by the same reader (CL) within the tracheal lumen three times, keeping reproducible sizes and locations; the mean SD value was used as the noise quantification.

Qualitative image analysis

Readers were asked to evaluate, independently and in a random order, both ULD-CT examinations using a 5-level scale (1 — non-diagnostic to 5 — excellent; detailed criteria in Table 3) with separate ratings of:

- the overall image quality;
- the image quality of the lung reconstructions;
- the image quality of the mediastinum reconstructions, resulting in 3 marks per reader and per ULD-CT volume (i.e., 6 marks per patients).

This qualitative analysis was based on the appreciation of the spatial resolution in terms of image's neatness, the identification of the anatomical structures and the amount and severity of the artifacts (noise and streak artifacts). Isolated respiratory motion artifacts were considered as a patient-related issue and were not taken into account in this qualitative evaluation. Image scores equal or greater than 3 were considered to be of diagnostic quality.

Subjective analysis

In a subsequent comparative reading, each radiologist was presented with the parenchymal reconstructions at 135 kVp and 80 kVp side-by-side and had to designate for every patient:

- which protocol (135 kVp or 80 kVp) provided the better image quality;
- the presence of any of 6 pre-listed parenchymal abnormalities (nodules > 5 mm, alveolar consolidation, interstitial septal thickening, ground glass opacity, bronchiectasis and fibrosis) and, if present, on which protocol (135 kVp, 80 kVp or both) these abnormalities were better identified/analyzed. Only lesions detected and analyzed by all 3 readers were ultimately taken into account.

Ultimately, for each patient, the following variables were obtained:

- demographics (sex, age, BMI and TTD);
- radiation dose in DLP and mSv;
- image noise at 80 kVp and 135 kVp;
- image quality (out of 5) at 80 kVp and 135 kVp;
- direct side-by-side comparison of 80 kVp and 135 kVp for global image quality and assessability of 6 parenchymal lesions.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) and ranges. Categorical variables were expressed as raw numbers, proportions and percentages.

Table 3 Detailed qualitative assessment.

	Overall image quality	Lung parenchyma	Mediastinum
1	Non-diagnostic image quality with major artifacts	Non-diagnostic	Non-diagnostic
2	Poor image quality with severe blurring causing uncertain evaluation	Secondary pulmonary nodule is not identified Lower lobar bronchi are difficult to distinguish from the surrounding parenchyma	Mediastinum vessels are merged and non-discernable Liver and spleen are not identified in the upper part of the abdomen
3	Acceptable image quality with moderate blurring and restricted assessment	Secondary pulmonary nodule is only discernable Lower lobar bronchi are hazy	Mediastinum vessels are difficult to identify Severe blurring of the liver and the spleen in the upper part of the abdomen
4	Good image quality with slight blurring but without restricted assessment	Fair depiction of the secondary pulmonary lobule Slight blurring of the lower lobar bronchi	Decent depiction of the mediastinum vessels Moderate blurring of the liver and the spleen in the upper part of the abdomen
5	Excellent image quality without any artifacts	Excellent depiction of the secondary pulmonary lobule Sharp margins of the lower lobar bronchi	Excellent delimitation of the mediastinum vessels Fair depiction of the upper part of the abdomen

Comparisons of continuous variables were performed using Student *t*-test for paired data or Wilcoxon paired test depending on the normality of the distribution, as established by a Shapiro—Wilk test. Correlations between quantitative variables were assessed using the Spearman correlation coefficient (Rho). Inter-reader agreement was assessed by computing Cohen's Kappa coefficient. Confidence intervals were calculated using the adjusted bootstrap percentile (method based on 10,000 replicates). Comparisons of proportion of diagnostic image quality between protocols and between BMI classes were performed using a logistic mixed regression. The correlation between patient values was handled through the unstructured covariance matrix of random effects. Statistical analysis testing was performed with the Language and Environment for Statistical Computing: R software in the more up-to-date version (R Core Team, R Foundation for Statistical Computing, version 3.1.0). For all tests, a P value < 0.05 was considered statistically significant.

Results

Population

Fifty-four patients were approached and three declined participation in the study. Fifty-one patients were ultimately included (Fig. 1). There were 29 men and 22 women, with a mean age of 64.7 ± 11.6 (SD) years (range: 35—91 years). Clinical indications for unenhanced chest CT included follow-up of pulmonary nodule (16/51 patients; 31%), suspicion of lung infections (11 patients; 21%), oncologic follow-up (9 patients; 18%), follow-up of interstitial pneumonia (6 patients; 12%) and other indications (9 patients; 18%). The mean BMI was 26.2 ± 6.3(SD) kg/m^2 (range: 17—54.9 kg/m^2). The mean TTD was 34.2 ± 3 (SD) cm (range: 28.2—43 cm).

Radiation dose

Acquisitions made at 80 kVp-40 mA were less irradiant than those made at 135 kVp-10 mA, with a mean DLP of 14.7 ± 1.8 (SD) mGy.cm (range: 11.3—18.9 mGy.cm) versus 15.6 ± 1.9 (SD) mGy.cm (range: 12.1—20.2 mGy.cm) (P < 0.001). The mean effective doses were 0.21 mSv at 80 kVp and 0.22 mSv at 135 kVp. This represents a 15-fold decrease compared to the SDD-CT (mean DLP of 218.9 ± 108.7 [SD] mGy.cm, range 97—594 mGy.cm, mean effective dose of 3.1 mSv).

Quantitative image analysis

Mean image noise was significantly lower with the 135 kVp ULD protocol (58.9 ± 12.4 [SD]; range: 41—117) than for 80 kVp ULD protocol (74.7 ± 14.5 [SD]; range: 51—138) (P < 0.001). This represents a 21% reduction in favor of the 135 kVp acquisitions. Image noise did not correlate with the BMI (correlation coefficient = —0.08, P = 0.57 for 135 kVp; correlation coefficient = 0.05, P = 0.72 for 80 kVp) nor with the TTD (Rho = —0.05; P = 0.73 for 135 kVp; Rho = —0.04; P = 0.79 for 80 kVp).

Qualitative image analysis

In total, 80 kVp and 135 kVp ULD protocols were qualitatively assessed for the overall image quality, the image quality of the lung reconstructions and the image quality of the mediastinum reconstructions. For all three criteria, the most given mark was 5 for 135 kVp and 4 for 80 kVp; qualitative image quality scoring was significantly higher for the 135 kV acquisition, for all readers (Table 4).

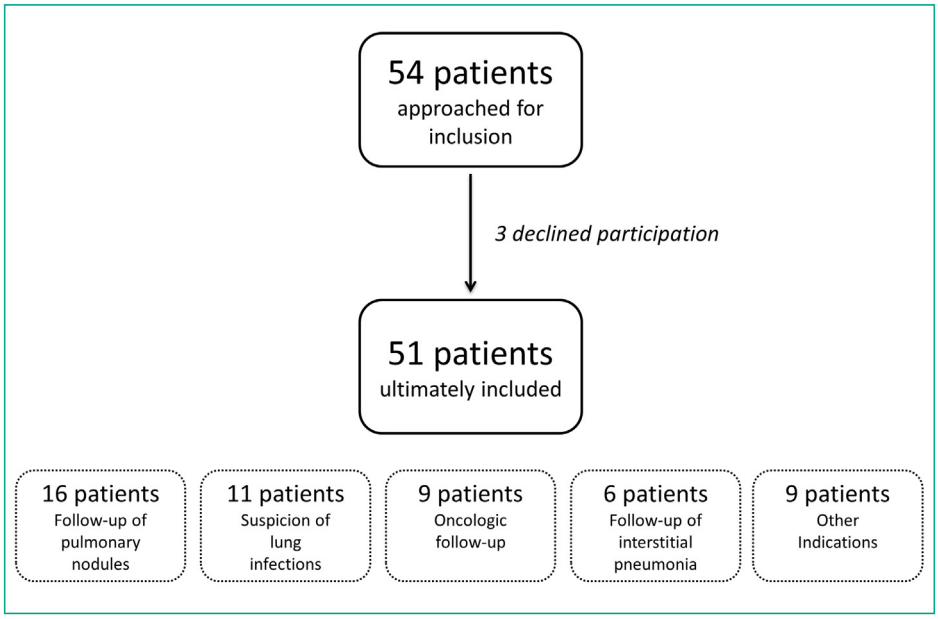

Figure 1. Flowchart of the study.

Table 4 Comparison of image quality marks.

	Overall analysis		Lung parenchyma analysis		Mediastinum analysis	
	80 kV-40 mA	135 kV-10 mA	80 kV-40 mA	135 kV-10 mA	80 kV-40 mA	135 kV-10 mA
Reader 1	3.8 ± 0.94 [1—5]	4.4 ± 0.74 [2—5]	3.9 ± 0.94 [1—5]	4.5 ± 0.75 [4—5]	3.5 ± 0.94 [1—5]	4.0 ± 0.74 [1—5]
Reader 2	3.9 ± 0.84 [2—5]	4.6 ± 0.75 [2—5]	4.2 ± 0.94 [1—5]	4.7 ± 0.65 [2—5]	3.6 ± 0.84 [1—5]	4.3 ± 0.75 [2—5]
Reader 3	4.0 ± 0.84 [1—5]	4.6 ± 0.65 [2—5]	4.2 ± 0.84 [1—5]	4.7 ± 0.65 [2—5]	3.4 ± 0.93 [1—4]	4.3 ± 0.74 [2—5]
P	*P* < 0.001		*P* < 0.001		*P* < 0.001	

Data are presented as mean ± standard deviation, median. Numbers in brackets are ranges [minimum — maximum].

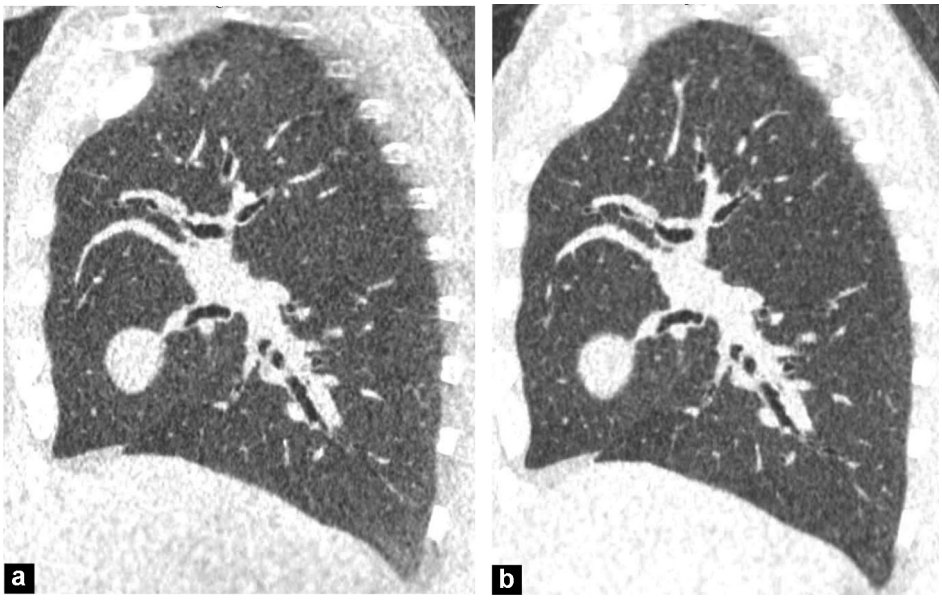

Figure 2. Ultra-low-dose CT image of the chest in the sagittal plane (lung window) acquired at 80 kVp (a) and at 135 kVp (b) in a 52-year-old man with a body mass index of 24.9 kg/m^2. The 135 kVp was rated higher by all three radiologists, with sharper margins in the apex and the base.

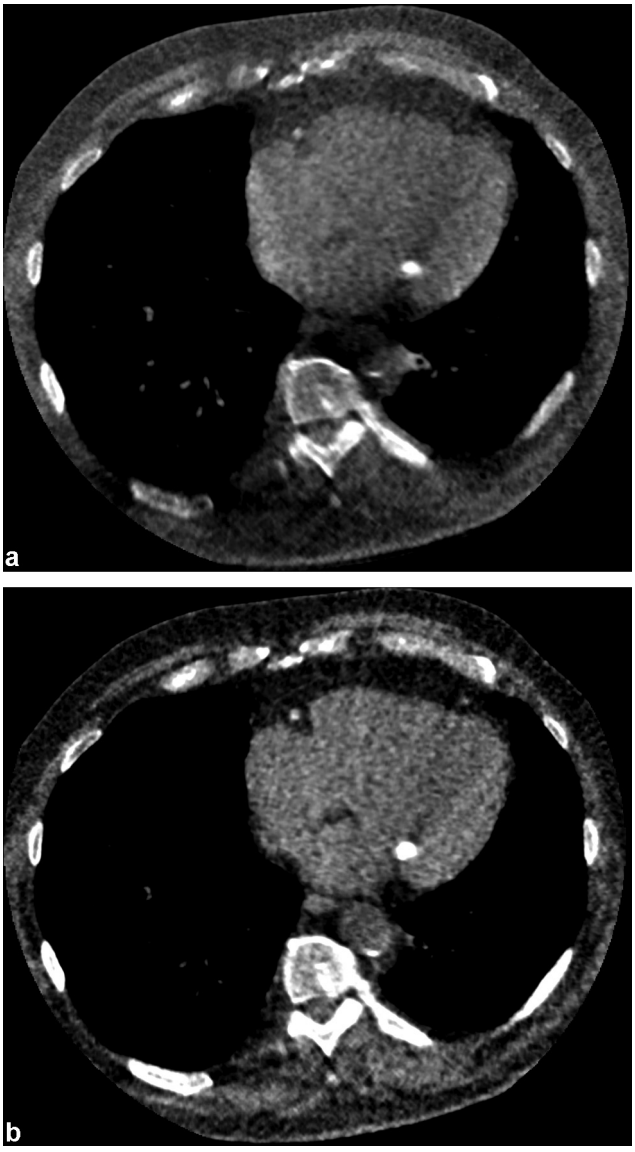

Figure 3. Ultra-low dose CT image of the chest in the transverse plane (mediastinal window) acquired at 80 kVp (a) and at 135 kVp (b) in a 74-year-old man with a body mass index of 32.7 kg/m^2. Image quality is significantly better at 135 kVp (b) than at 80 kVp (a).

The proportion of examinations of diagnostic quality (i.e. score $\geq$ 3) was significantly higher for the 135 kVp (142 ratings out of the 153 made by all 3 readers; 92.8%) than with the 80 kVp ULD protocol (119 ratings; 77.8%) ($P < 0.001$). Examples are given in Figs. 2 and 3. For all these qualitative scores, the inter-reader agreements were substantial with a Cohen's κ between 0.68 and 0.78.

Subjective analysis

The 135 kVp acquisition was preferred over the 80 kVp for 100% of patients and for all three readers. Sixty-nine parenchymal lesions were detected and analyzed by all 3 readers. Depending on the reader, lesions were better seen on the 135 kVp acquisition in 51% (35/69 lesions) to 57% (39/69 lesions) of examinations and were equally seen on both acquisitions in 43% (30/69 lesions) to 49% (34/69 lesions) of patients. In no lesions the 80 kVp ULD protocol provided a better depiction than the 135 kVp ULD protocol. Detailed results by reader and by lesion are given in Table 5.

Influence of BMI on image quality

Mean image quality between both protocols was compared between normal (BMI < 25 kg/m^2), overweight (BMI between 25 and 30 kg/m^2) and obese (BMI > 30 kg/m^2) patients. The proportion of diagnostic quality examinations was significantly different between the 135 kVp acquisition and the 80 kVp for obese patients (70% for 135 kVp versus 36.7% for 80 kVp) ($P = 0.03$) (Table 6). An example is shown in Fig. 4.

Discussion

The results of our study demonstrate the quantitative and qualitative superiority of the ''135 kVp-10 mA'' ULD-CT protocol compared to the ''80 kVp-40 mV'' for unenhanced chest CT. With an equivalent radiation dose, the high voltage-low current acquisition has a significantly lower image noise, gets significantly higher image quality marks and is preferred over the low voltage-high current protocol for every patient and for the majority of parenchymal lesions. In addition, it is statistically more frequently of diagnostic quality, particularly in obese patients. These findings hold true for all three readers.

Concern over radioprotection has naturally increased over the past few decades in light of the growing use of ionizing radiation for medical imaging [2]. It is based on three main principles, which are the limitation, the justification and the optimization of the dose delivered. Unenhanced chest CT is an excellent candidate for optimizing the radiation dose, due to the high intrinsic contrast of the lung parenchyma [9,10]. However, radiation dose reduction results in an increase in noise and an alteration in spatial resolution, which is now partially compensated by the use of iterative reconstruction. Indeed, newest iterative reconstruction algorithms decrease noise as well as a certain number of artifacts in comparison to the classical filtered back projection [21,22]. When acquiring a ULD-CT examination, radiation dose is drastically reduced and image quality purposefully lowered, while still remaining informative. Consequently, various studies have been published confirming the diagnostic performances of ULD-CT [12—17] for lung parenchyma analysis, but they all exhibited a wide variety of acquisition protocols (Table 1), even though the final radiation doses were similar and kept below 0.3 mSv.

This study has compared the two main ULD-CT acquisition protocol alternatives (i.e., high kV-low mA versus the low kV-high mA). Both ULD-CT acquisitions parameters have been chosen to attain the same radiation level, similar to that of a frontal and lateral chest X-ray [23]. We found that the radiation dose between the two protocols is statistically different, but with a marginal difference of 0.01 mSv (a reduction of less than 6%). We have no explanation for this difference, since CTDIvol and FOV were identical between both acquisitions.

The use of a high voltage-low current ULD protocol has several benefits. One advantage one is a reduced number of major artifacts, mainly on the pulmonary apex at the

Table 5 Qualitative side-by-side comparison of 6 predetermined parenchymal abnormalities.

	Reader 1			Reader 2			Reader 3		
	135 kV > 80 kV	80 kV > 135 kV	135 kV ↔ 80 kV	135 kV > 80 kV	80 kV > 135 kV	135 kV ↔ 80 kV	135 kV > 80 kV	80 kV > 135 kV	135 kV ↔ 80 kV
Nodule ≥ 5 mm (*n* = 27 in 17 patients)	13/27 (48%)	0/27 (0%)	14/27 (52%)	15/27 (56%)	0/27 (0%)	12/27 (44%)	17/27 (63%)	0/27 (0%)	10/27 (37%)
Alveolar consolidation (*n* = 16 in 7 patients)	5/16 (31%)	0/16 (0%)	11/16 (69%)	3/16 (19%)	0/16 (0%)	13/16 (81%)	2/16 (13%)	0/16 (0%)	14/16 (87%)
Bronchiectasis (*n* = 9 in 9 patients)	5/9 (56%)	0/9 (0%)	4/9 (44%)	2/9 (22%)	0/9 (0%)	7/9 (78%)	5/9 (56%)	0/9 (0%)	4/9 (44%)
Interstitial septal thickening (*n* = 8 in 8 patients)	7/8 (88%)	0/8 (0%)	1/8 (12%)	8/8 (100%)	0/8 (0%)	0/8 (0%)	8/8 (100%)	0/8 (0%)	0/8 (0%)
Ground glass opacity (*n* = 6 in 6 patients)	4/6 (67%)	0/6 (0%)	2/6 (33%)	5/6 (83%)	0/6 (0%)	1/6 (17%)	5/6 (83%)	0/6 (0%)	1/6 (17%)
Fibrosis (*n* = 3 in 3 patients)	2/3 (67%)	0/3 (0%)	1/3 (33%)	2/3 (67%)	0/3 (0%)	1/3 (33%)	2/3 (67%)	0/3 (0%)	1/3 (33%)
All lesions (*n* = 69)	36/69 (52%)	0/69 (0%)	33/69 (48%)	35/69 (51%)	0/69 (0%)	34/69 (49%)	39/69 (57%)	0/69 (0%)	30/69 (43%)

''135 kV > 80 kV'' means that the reader found that the lesion was best visualized/analyzed on the 135 kV acquisition, ''80 kV > 155 kV'' on the 80 kV acquisition, and ''135 kV ↔ 80 kV'' on both indistinctly.

Table 6 Proportion of diagnostic image quality according to body mass index.

BMI (kg/m^2)	Number of patients (%)	Frequency of diagnostic image quality		*P*
		80 kV-40 mA	135 kV-10 mA	
BMI $\leq$ 25	29 (57%)	78/87 (89.7%)	86/87 (98.9%)	0.08
25 < BMI $\leq$ 30	12 (23%)	30/36 (83.3%)	35/36 (97.2%)	0.2
BMI > 30	10 (20%)	11/30 (36.7%)	21/30 (70.0%)	0.03*

BMI: body mass index.
* p<0.05

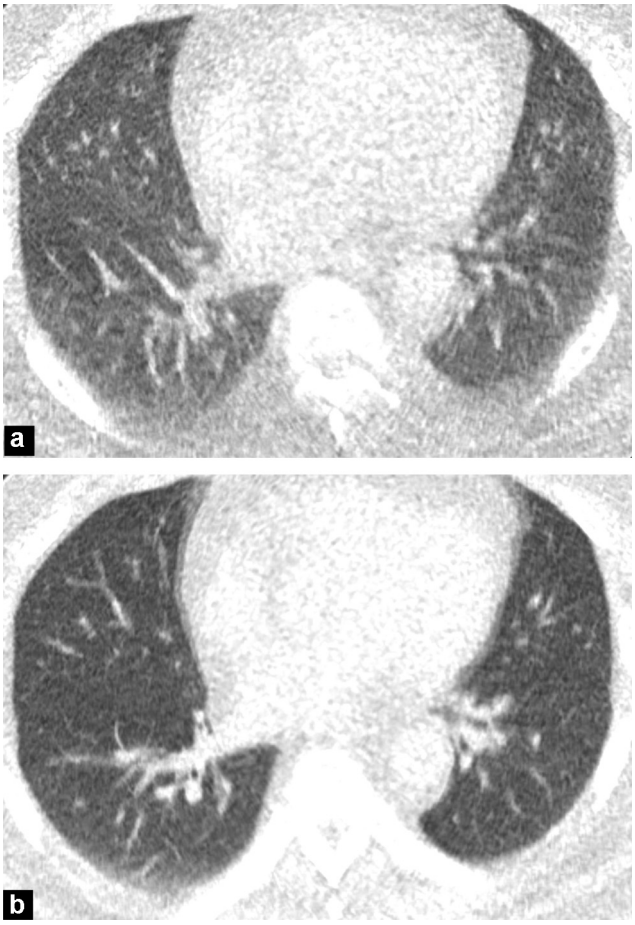

Figure 4. Ultra-low dose CT image of the chest in the transverse plane in (lung window) acquired at 80 kVp (a) and at 135 kVp (b) in a 52-year-old man with a body mass index of 32 kg/m^2. 135 kVp acquisition (b) is still informative, while the 80 kVp one (a) can be considered non-diagnostic.

level of the shoulders. Indeed, low energy photons are more attenuated than high-energy photons when they cross-dense structures such as bone, causing beam-hardening artifacts [24]. A second advantage is a theoretical reduction of the radiation dose delivered to the skin, the breast and the thyroid, as high kV X-rays are characterized by an excellent penetration and a reduced absorption in the superficial soft-tissues [25]. A third advantage is the BMI's minimal influence on image quality for obese patients. This protocol is indeed more robust to image deterioration in obese patients, as we demonstrated a significantly higher proportion of diagnostic quality examinations in patients with a BMI > 30 kg/m^2. This is all the more interesting as one of today's main limitations of dose reduction is patient's morphotype. Lee et al. demonstrated a lower diagnostic performance of ULD-CT for patients with BMI > 25 kg/m^2 [18], while in our study this effect was found only for patients with a BMI > 30 kg/m^2. Future studies should validate the use of ULD-CT in patients with a BMI between 25 and 30 kg/m^2.

Our study has some limitations. One relates to the different appearance of images acquired with the two protocols, with the ability for an experienced reader to identify both ULD-CT acquisitions, based on the artifacts and fat density. However, the junior reader, who was unaware of these subtleties, graded the examinations in the same way (substantial inter-reader agreement with the two experienced readers). Another significant limitation is that the qualitative analysis is only based on the subjective appreciation of the image quality and lesion assessability. One would have preferred to have an evaluation based on diagnostic performance, i.e. comparing the sensitivity and specificity of both ULD-CT protocols to the reference SDD-CT. However, we were not able to choose this approach as it would have required many more patients to be statistically significant. Future studies should focus on the potential gain in diagnostic performance of a high kVp-low mA ULD-CT protocol. We hypothesize that the higher image quality and lesion assessability demonstrated in this preliminary work should translate in increased diagnostic performance. One last limitation is that this work is vendor specific. Since the effects of all current-generations IR are analogous, we do believe that our results can be generalized. Future studies with other scanners and IR algorithms should be conducted to validate our findings.

In conclusion chest ULD-CT protocol at 135 kVp and 10 mA offers a higher image quality from a qualitative and quantitative perspective compared to 80 kVp and 40 mA, while being less prone to image quality deterioration in obese patients. This acquisition protocol could be considered as a radiation dose optimization approach for chest CT in routine practice.

Disclosure of interest

The authors declare that they have no competing interest.

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