Original Article

Applicability of color-coded computed tomography images in lung volume reduction surgery planning

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Background: Adequate patient selection is the key to successful lung volume reduction in patients with pulmonary emphysema. Computed tomography (CT) enables a reliable detection of pulmonary emphysema and allows an accurate quantification of the severity. Our goal was to investigate the usefulness and reliability of color-coded (CC) CT images in classification of emphysema and preoperative lung volume reduction planning.

Methods: Fifty patients undergoing lung volume reduction surgery at our institution between September 2015 and February 2016 were retrospectively investigated. Three readers visually assessed the amount and distribution patterns of pulmonary emphysema on axial, multi-planar and CC CT images using the Goddard scoring system and a surgically oriented grading system (bilateral markedly heterogenous, bilateral intermediately heterogenous, bilateral homogenous and unilateral heterogenous emphysema). Observer dependency was investigated by using Fleiss' kappa (κ) and the intraclass correlation coefficient (ICC). Results were compared to quantitative results from densitometry measurements and lung perfusion scintigraphy by using Spearman correlation. Recommendations for lung volume reduction sites based on emphysema amount and distribution of all readers were compared to removal sites from the surgical reports.

Results: Inter-rater agreement for emphysema distribution rating was substantial for CC images (κ=0.70; 95% CI, 0.64–0.80) and significantly better compared to axial and multiplanar images (P≤0.001). The inter-rater agreement for recommended segment removal was moderate for CC images (κ=0.56; 95% CI, 0.49–0.63) and significantly better compared to axial and multiplanar images (P<0.001). Visual emphysema rating correlated significantly with measurements from densitometry and perfusion scintigraphy in the upper and lower lung zones in all image types.

Conclusions: CC CT images allow a precise, less observer-dependent evaluation of distribution of pulmonary emphysema and resection recommendation compared to axial and multiplanar CT images and might therefore be useful in lung volume resection surgery planning.

Keywords: Pulmonary emphysema; densitometry; pneumonectomy; tomography, spiral computed; pulmonary disease; chronic obstructive

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Introduction

Pulmonary emphysema is a long-term, irreversible pneumopathy defined as an abnormal permanent enlargement beyond the terminal bronchioles due to a destruction of lung parenchyma (1,2). Emphysema is one manifestation of a group of obstructive, chronic and often progressive lung diseases, i.e., chronic obstructive pulmonary disease (COPD) (3).

There are only limited treatment options available for patients with severe emphysema. Among them, lung volume reduction surgery (LVRS), may improve respiratory mechanics by removing damaged lung tissue (4). Since its introduction in 1990s, many studies investigated patient selection for LVRS and revealed that correct identification of the type of emphysema distribution is of great importance regarding success of this type of surgery (5-9).

Ever since, imaging modalities play an important role in the diagnosis of pulmonary diseases and computed tomography (CT) has evolved to be the principal and most widely used diagnostic tool for detailed imaging of lung parenchyma (10,11). Imaging of the lungs using CT enables a reliable detection of pulmonary emphysema and moreover allows an accurate quantification of the severity.

Basically, there are two different techniques available for the assessment and quantification of pulmonary emphysema in CT. First the semi-quantitative, where an experienced radiologist or clinician performs a subjective visual grading of the severity of pulmonary emphysema using a pre-defined numerical score chart. By contrast, the quantitative approach enables an automated assessment of the pulmonary emphysema depicting emphysematous areas as low attenuation areas (LAAs) in respect of a defined threshold value ranging from −900 Hounsfield unit (HU) to −950 HU (12,13). On the other hand, Technetium-99m macro aggregated albumin (^{99m}Tc-MAA) perfusion scintigraphy may further aid in identifying target areas of resection in LVRS patients with homogenous emphysema distribution (14).

Since the correct identification of the present type of emphysema distribution belongs to the most important factors to estimate the clinical outcome after LVRS, we developed a color-coded (CC) imaging of the emphysematous lung using the quantitative approach. The purpose of this study was to investigate the reliability of the new visualisation type on classification of emphysema and preoperative resection planning.

Methods

Subjects

We retrospectively investigated all patients undergoing thoracoscopic LVRS at our institution between September 2015 and February 2016. The local ethics committee approved the study (EC-No. 2014-0275). Inclusion criteria were availability of a preoperative CT-scan and Technetium ^{99m}TC macro aggregated albumin (^{99m}Tc-MAA) perfusion scintigraphy.

CT protocol

All subjects underwent a preoperative CT at full inspiration and full expiration using a standard CT protocol. All scans were acquired with tube current modulation (mA modulation) to ensure correct patient exposure and reduce patient dosis and voltage was selected according to the patient size and ranged between 120–140 kVp. The protocol further included reconstructions with 2 mm slice-thickness and tissue convolution kernel as well as lung window settings (15). Our standard protocol did not include intravenous contrast medium since higher lung parenchyma densities are detected when contrast medium is administered (16,17). All CT scans were acquired during a single breath-hold.

Image processing

Three types of datasets were prepared for the readout: (I) axial high resolution CT slices with 2 mm slice thickness in lung window (W/L: 1,600/−700 HU), further called “axial images”; (II) sagittal and coronal reconstructed high resolution CT slices with 2 mm slice thickness in lung window, further called “MPR images” (multiplanar reconstruction images); and (III) CC images, using density mask technique, in all three dimensions depicting the subranges using a dedicated automated software (3viseon 3.5, 3mensio medical imaging, The Netherlands), further called “CC images”. The density mask technique settings were as follow: ranges of 40 HU per color starting from −1,000 to −760 HU, using red for the range from −1,000 to −960 HU corresponding severe emphysema and green for the range of −800 to −760 HU corresponding normal lung tissue.

Visual assessment of CT

Three readers (reader 1, radiologist with 9 years of experience in thoracic imaging; reader 2, radiologist with 5 years of experience in thoracic imaging, and reader 3, thoracic surgeon, with 5 years of experience) assessed all patients on axial, MPR and CC lung images. All images were displayed on PACS workstation (AGFA HealthCare, Mortsel, Belgium). The readers evaluated the images three times with an interval of 3 weeks starting with the axial images. All readers were blinded to information regarding the patients' clinical data, the results of quantitative assessment and results from surgery. Emphysema distribution was visually assessed using a surgically oriented grading system, based on differences in the extent of lung destruction in adjacent lung segments: bilateral markedly heterogenous, bilateral intermediately heterogenous, bilateral homogenous and unilateral heterogenous emphysema (5,18,19). Each lung was divided into three zones: the upper zone (extending from the apices to the aortic arch), the mid zone (extending from the aortic arch to the level of the tracheal bifurcation), and the lower zone (extending from the tracheal bifurcation to the level of the diaphragm). The amount of emphysema was visually graded according to the modified Goddard scoring system (20) —0: no signs of emphysema; 1: 1–25%; 2: 26–50%; 3: 51–75%; and 4: >75% of emphysema, respectively. Each reader furthermore noted up to 6 lung zones (upper right/left including the apical upper lobe; middle right/left including the basal upper lobe, and the superior lower lobe; basal right/left including the basal lower lobe, middle lobe/lingula) per patient which he would recommend for removal during LVRS based to its emphysema amount and the global emphysema distribution.

Quantitative assessment of CT

The amount of pulmonary emphysema defined as the percentage of lung parenchyma below the predefined threshold of −950 (LAA%, LAA/total lung volume) was automatedly calculated using dedicated segmentation software (Ziostation2, Ziosoft, Tokyo, Japan). All larger airways were excluded from the analysis. A medical student assessed the segmentation and performed corrections if necessary.

Lung perfusion scintigraphy

Planar lung perfusion scintigraphy was performed using a dedicated scanner (Discovery NM/CT 670 or Infinia Hawkeye, GE Healthcare, Waukesha, WI, USA) after intravenous injection of 180±20 MBq by ^{99m}Tc-MAA (^{99m}Tc-Technetium-Macrosalb MAASOL, GE Healthcare) in anterior, posterior, right lateral, left lateral, left posterior oblique, and right posterior oblique view (140 keV ±10%, LEHR collimator; matrix: 256×256, acquisition time: 101 s) The amount of perfusion defined as % of the total measured ^{99m}Tc-MAA activity on 2D plane was calculated using three equal rectangular regions of interest (ROI) on the anterior and posterior views: top, middle, and bottom. The counts in each ROI were divided by the total counts over the lung measured from the anterior and posterior view.

LVRS surgery

All patients were operated by unilateral or bilateral video assisted thoracic surgery LVRS or by thoracotomy in the case of adhesions. Targeted lung tissue for resection was chosen based on preoperative radiological assessment using the above-mentioned images and intraoperative findings of trapped air and perfusion and were removed by using atypical resection and/or lobectomy (21,22). None of the readers were involved in the preoperative multidisciplinary emphysema treatment board, where all candidates for LVRS were discussed by thoracic surgeons, pulmonologists and radiologists.

Statistics

The statistical analysis was performed in R version 3.5 (R Foundation for Statistical Computing, Vienna, Austria). Inter-rater agreement for nominal data was assessed using Fleiss' kappa (κ) and confidence intervals (CI) were calculated using resampling with bootstrapping (23). Inter-rater reliability for ordinal data was assessed with the intraclass correlation coefficient (ICC) (24). Inter-rater agreement was interpreted according to Landis and Koch—almost perfect: 0.8–1.00; substantial: 0.61–0.80; moderate: 0.41–0.60; fair: 0.21–0.40; slight: 0.00–0.20; poor: <0.00 (25). Inter-rater reliability was interpreted after the suggestion of Cicchetti and Sparrow—excellent agreement: >0.75; good agreement: 0.59–0.75; fair agreement: 0.40–0.58; and poor agreement: <0.40 (26). Association between nominal data was evaluated using χ^2 and Cramer's V coefficient. Spearman correlation coefficient (ρ) was used to assess correlation between ordinal and continuous data and

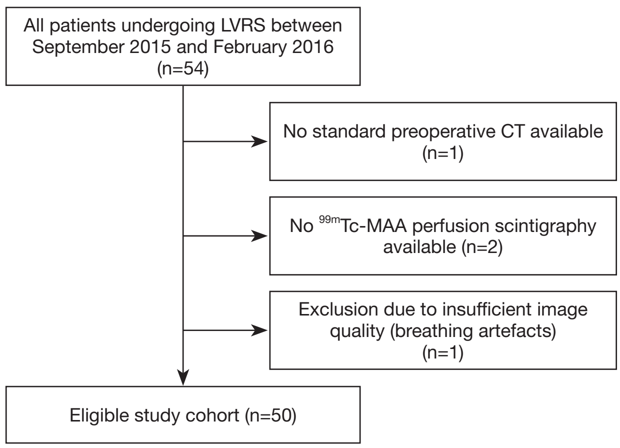

Figure 1 Flow chart of study population selection. LVRS, lung volume reduction surgery.

Table 1 Demographics of study patients (n=50)

Variable	Number
Female/male	22/28
Age at CT scan, years	63 [42–84]
Time between CT and perfusion scintigraphy, days	53 [0–418]
CT before scintigraphy	28 (56%)
CT after scintigraphy	7 (14%)
CT and scintigraphy on same day	15 (30%)
Time between CT and LVRS, days	49 [1–267]

Data presented as n, mean [range], or n (%). CT, computed tomography; LVRS, lung volume reduction surgery.

among continuous data. A P value of less than 0.05 were considered statistically significant. Bonferroni correction was applied when appropriate.

Results

Fifty patients fulfilled all criteria and were included. Selection of the study population is shown in *Figure 1*. A total of 150 axial, MPR and CC CT image sets were assessed by the three readers. The analysis included a total of 133 lung zones involved in LVRS. Ninety-four percent (47/50) of the patients had atypical resection and 6% (3/50) had lobectomy and atypical resection. Eighteen percent (9/50) of the patients had a unilateral LVRS, 82% (41/50) had a bilateral LVRS. Demographics and further details of the study population is given in *Table 1*. Example of a preoperative CT scan including axial, multiplanar and CC images is depicted in *Figure 2*.

Observer dependency

Inter-rater agreement for emphysema distribution rating was fair for axial and MPR (κ=0.26; 95% CI, 0.11–0.37 and κ=0.40; 95% CI, 0.22–0.50) and moderate for CC images (κ=0.70; 95% CI, 0.64–0.80), respectively. Inter-rater agreement was significantly better for CC images compared to axial (P≤0.001) and MPR images (P≤0.001). Results of the visual emphysema distribution rating is illustrated in *Figure 3A*. ICC for emphysema amount rating was good (0.77; 95% CI, 0.72–0.81) for axial, fair for MPR (0.60; 95% CI, 0.51–0.67) and good for CC images (0.74; 95% CI, 0.68–0.79), respectively. The inter-rater agreement for recommended segment removal was fair for axial and MPR images (κ=0.33; 95% CI, 0.26–0.39 and κ=0.39; 95% CI, 0.32–0.46, respectively) and moderate for CC images (κ=0.56; 95% CI, 0.49–0.63). Inter-rater agreement was significantly better for CC images compared to axial (P≤0.001) and MPR images (P≤0.001).

Association between image type and emphysema distribution

Visual emphysema distribution scores were significantly associated with the image type (χ^2=24.149, df =6, P value <0.001). Emphysema was more frequently scored as bilateral markedly heterogenous emphysema on CC images compared to axial and MPR images (Cramer's V =0.164, 95% CI, 0.12–0.24). Details of the readout of reader 1 are shown in *Figure 3B*. Combined contingency table of the emphysema distribution scores of readers 1–3 is shown in *Table 2*.

Correlation with quantitative CT

Visual emphysema amount of all images correlated significantly with the measured amount of emphysema in the upper and lower lung zones (ρ ranged between 0.39–0.48 in the upper lung zones and between 0.39–0.40 in the lower lung zones, all P value <0.001). There was no significant correlation between emphysema amount rating and measured amount of emphysema in middle zones (ρ ranged between 0.15–0.18, P value ranged from 0.194–0.679).

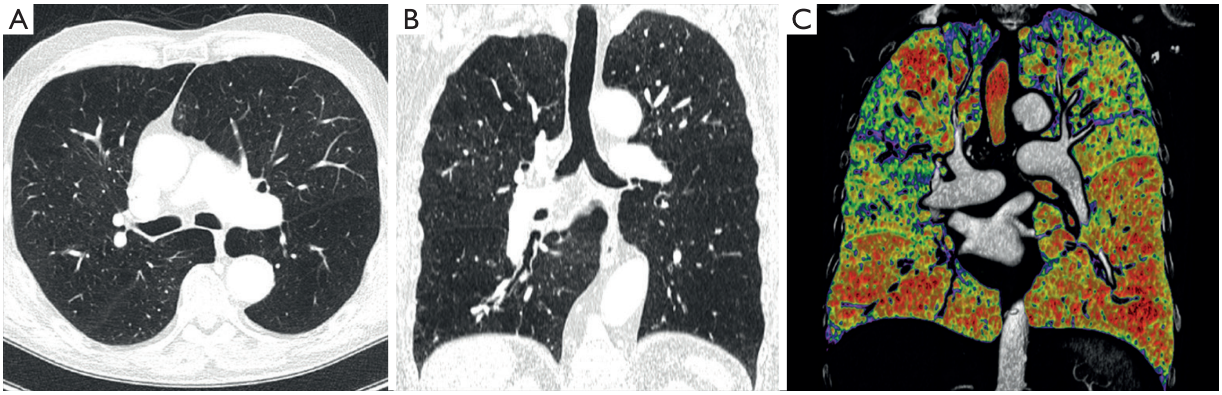

Figure 2 Preoperative CT of a 79-year-old subject with COPD Gold IV. (A) Axial, (B) multiplanar (MPR), and (C) color-coded (CC) CT images. Emphysema distribution scoring by three readers was as follows: 2× unilateral heterogenous and 1× bilateral intermediately heterogenous on axial images, 2× unilateral intermediately heterogenous and 1× bilateral intermediately heterogenous on MPR images and 3× bilateral heterogenous on CC images. COPD, chronic obstructive pulmonary disease.

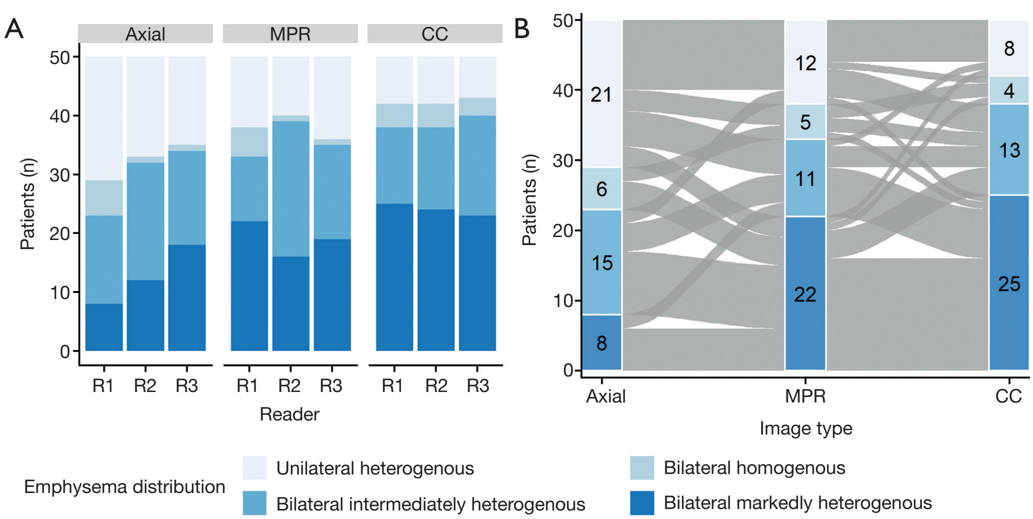

Figure 3 Emphysema distribution rating results. (A) Stacked bar plots of the scores of the emphysema distribution readout [on axial, multiplanar (MRP) and color-coded (CC) images] for readers 1–3 (x-axis) and absolute count of the different emphysema distribution scores (y-axis). (B) Sankey network plot showing emphysema distribution scores of reader 1 per n patient (y-axis) for axial, MRP and CC images (x-axis). Note the detailed differences between the reformations (ribbons linking the reformations).

Table 2 Combined contingency table of emphysema distribution scores of readers 1–3

Image type	Scores			
	Bilateral markedly heterogenous	Bilateral intermediately heterogenous	Bilateral homogenous	Unilateral heterogenous emphysema
Axial	38	51	8	53
MPR	57	50	7	36
CC	72	44	11	23

CT, computed tomography; MPR, multiplanar reconstruction.

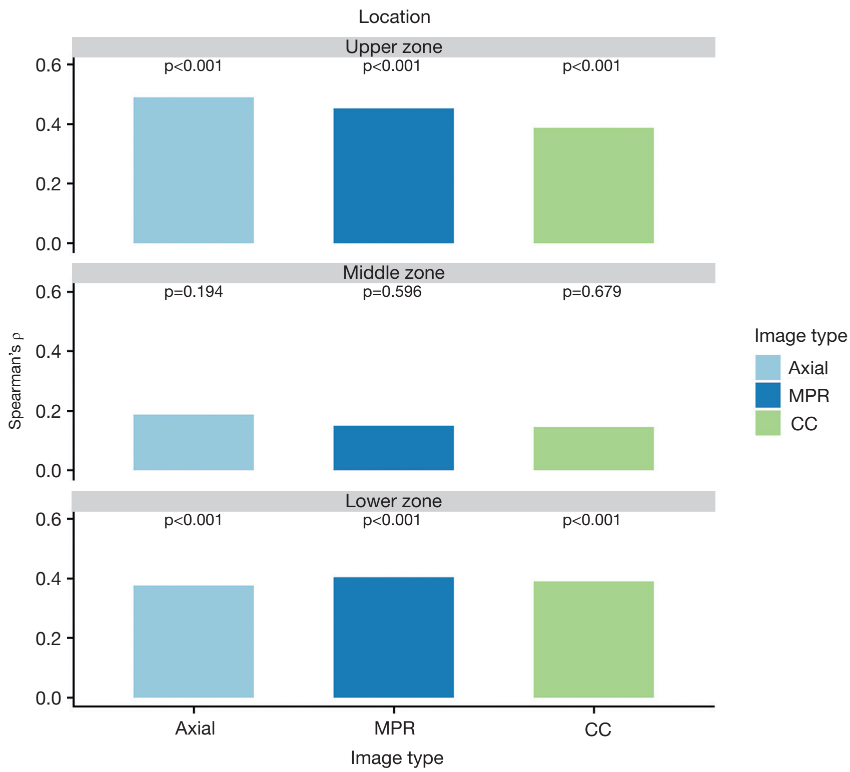

Figure 4 Bar plots representing Spearman's ρ (y-axis) of visual emphysema scores and measured emphysema amount per CT-reformation (x-axis) for different lung zones. Note the significant correlation between visual emphysema score and measured emphysema amount in the upper and lower zones for all reconstructions.

All correlation results are visually summarized in *Figure 4* for further details see *Table S1*. Emphysema amount was overestimated in most of all analysed zones on all images [in 79.3% (714/900) zones of axial, 80.7% (726/900) zones of MPR and 78.8% (709/900) of zones in CC images, respectively].

Correlation with lung perfusion scintigraphy

Visual emphysema amount of all image types showed a significantly negative correlation with perfusion measurements from lung perfusion scintigraphy in the upper and lower zones (P value ranged between 0.001 and <0.001 and 0.004 and <0.001, respectively). There was no significant correlation between visual emphysema amount and perfusion measurements for the middle zones (P value ranged between 0.105–1). Correlation results are depicted in *Figure 5* and detailed results for each reader 1–3 are summarized in *Table S2* in the electronic supplementary material.

Association between recommended zones for removal and surgery

CT-based, recommended zones for removal during LVRS were significantly associated with the removed segments during surgery for all types of images: axial (χ^2=1,040, df =36, P value =0; Cramer's V =0.59, 95% CI, 0.54–0.61), MPR (χ^2=991.7, df =36, P value ≤0.001, Cramer's V =0.57, 95% CI, 0.53–0.60) and CC (χ^2=1,032.8, df =36, P value =0; Cramer's V =0.58, 95% CI, 0.53–0.60). Agreement between preoperative suggestions and results from surgery is depicted in *Table 3*.

Discussion

Our results show that the use of CC images is less observer-dependent in characterizing emphysema distribution patterns and providing recommendations for resection compared to axial and multiplanar CT images. The CC image-based quantification of emphysema showed similar

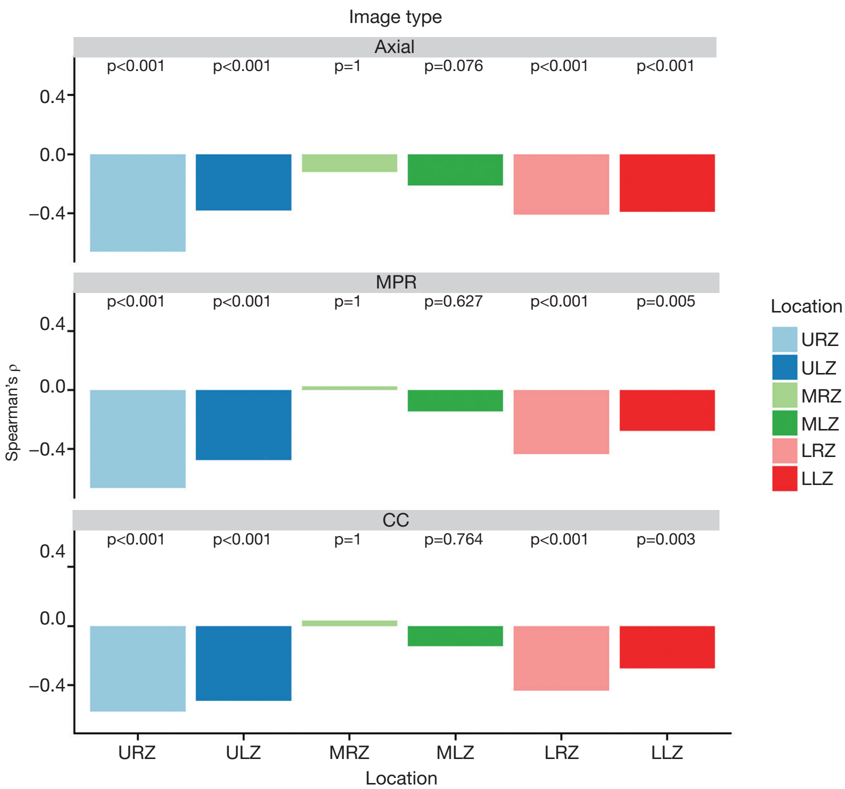

Figure 5 Bar plots representing Spearman's ρ (y-axis) of visual emphysema scores of three readers on axial, multiplanar (MRP) and color-coded (CC) images and measured perfusion percent with scintigraphy per lung location. URZ, upper right zone; ULZ, upper left zone; MRZ, middle right zone; MLZ, middle left zone; LRZ, lower right zone; LLZ, lower left zone.

correlation to quantitative CT compared to axial or multiplanar CT images.

Early studies showed good correlation between patients with marked heterogeneity in the severity of pulmonary emphysema and functional outcome LVRS (27,28). The National Emphysema Treatment Trial (NETT) revealed patients with heterogenous emphysema in the upper lobes and low exercise capacity as best responders to LVRS (9,29). Since recent studies suggest a broader spectrum of patients with different distributions of emphysema suitable for LVRS (30-34) and case selection as well as a multidisciplinary approach play relevant roles in the outcome of LVRS programs (35,36), observer-independent imaging methods that can reliably depict areas with severe emphysema are of great importance.

Some evidence suggests, that also patients with homogeneous emphysema can profit from LVRS (30). However, it is important that harm and benefit is well balanced for this population group. Furthermore, a careful preoperative planning is crucial. Although current automated lung emphysema quantification software provides a wealth of quantitative information, they are not designed to provide a classification of the different types of emphysema distributions. The latter is important for LVRS planning and outcome (5,8,19,37). The surgically oriented grading system of emphysema distribution used in this study plays an important role at our institution for preoperative assessment and is well established, although it has not yet been investigated regarding inter-reader agreement.

For standard CT based assessment of emphysema Hersh *et al.* reported a poor interobserver agreement among 5 readers (radiologists and pulmonologists) in determination of upper lobe-predominant disease on CT scans of 30 patients with emphysema (38). Bankier *et al.* reported moderate interobserver agreement of visual grading of emphysema on grey-scale images (12). Mohsen *et al.* also found improved inter-rater agreement of visual quantitation of emphysema using a simple density mask compared to grayscale scale images, however, the authors did not take specific lung zones into consideration in this study (39). In

Table 3 Agreement of recommended resection zones of all 3 readers based on axial, MPR and CC images regarding resected zones during surgery

Image type	Surgery						
	0	URZ	ULZ	MRZ	MRZ	LRZ	LLZ
Axial							
0	0	27	26	10	15	60	40
URZ	19	66	0	0	0	0	0
ULZ	18	0	67	0	0	0	0
MRZ	23	0	0	20	0	0	0
MLZ	21	0	0	0	24	0	0
LRZ	9	0	0	0	0	18	0
LLZ	11	0	0	0	0	0	26
MPR							
0	0	23	27	15	16	59	44
URZ	17	70	0	0	0	0	0
ULZ	19	0	66	0	0	0	0
MRZ	20	0	0	15	0	0	0
MLZ	17	0	0	0	23	0	0
LRZ	12	0	0	0	0	19	0
LLZ	19	0	0	0	0	0	22
CC							
0	0	19	23	12	23	56	40
URZ	19	75	0	0	0	0	0
ULZ	21	0	71	0	0	0	0
MRZ	18	0	0	18	0	0	0
MLZ	20	0	0	0	16	0	0
LRZ	14	0	0	0	0	22	0
LLZ	20	0	0	0	0	0	26

MPR, multiplanar reconstruction; CC, color-coded; 0, no agreement between CT-based recommendation/surgery; URZ, upper right zone; ULZ, upper left zone; MRZ, middle right zone; MLZ, middle left zone; LRZ, lower right zone; LLZ, lower left zone.

the present study, CC images lead to a substantial inter-rater agreement regarding the grading of emphysema distribution compared to axial or MPR images. In addition, we observed a shift from initially homogeneous rated scans on axial images towards heterogeneous rated scans on CC images and the inter-reader agreement of emphysema distribution on CC images improved. These two facts are responsible for the third finding, which is the substantial inter-rater agreement in providing recommendations for lung segment resection for LVRS on CC images. Furthermore, the selected segments are well associated with the final resected lung. In consequence, the CC images allow readers to define the areas for resection more accurately than on axial images.

Our results showed a significant correlation between subjective emphysema ratings and quantitative CT measurements. This is in accordance with a previously published study, analyzing correlations of MPR reformations between subjective scores on axial CT-images and densitometric measurements, even though, this study did not investigate specific lung zones (12). There was no significant correlation between emphysema amount rating and measured amount of emphysema in the middle zones. The reason therefore might be by aggravated anatomical localisation of this region. In the present study the amount of emphysema was visually generally overestimated compared to emphysema measurements. This is in accordance with Bankier *et al.*, reporting that radiologists tended to relatively overestimate emphysema in patient with severe emphysema, which could result from the fact, that readers have the tendency to err on the side of caution under test conditions (12).

When comparing the CT-based data with lung scintigraphy, the visual emphysema amount rating of all image types showed a significantly negative correlation with perfusion measurements from scintigraphy in the upper and lower zones, indicating that perfusion scintigraphy may help to identify target areas for resection in LVRS as suggested by Thurnheer *et al.* (14). Missing correlation between quantitative CT measurements and perfusion scintigraphy of the middle zones remains unclear. This result could be caused by aggravated anatomical localisation of these regions in combination by the fact that CT and scintigraphy measure different properties of the lungs, namely anatomy/structure and circulation, which is, of course, also correct for all other zones, but has more influence close to the perihilar structures. Furthermore, results from the perfusion scintigraphy presented in this study did not consider information from the CT and therefore differentiation of perfusion defects due to obstruction and von Euler-Liljestrand effects or irreversible lung destruction was limited in the perfusion scintigraphy.

The reason to develop a method that additionally illustrates the severity and distribution of the pulmonary emphysema was not to implement a competitive process against already implemented and accepted quantitative imaging approaches, but rather to develop a method that helps surgeons to determine their decision for an invasive therapeutic procedure. While it enables a less observer-dependent overview of the severity and distribution of pulmonary emphysema, it is easily and quickly to acquire by using any software providing density mask technique.

Our study has limitations that need to be considered. First, this is a retrospective single-center study with its inherent limitation, and therefor conclusions drawn from the present analysis await further proof in larger (and ideally multi-centric) observations. Nevertheless, all types of emphysema were represented in a sufficient number of cases. A second limitation is the missing consideration of other factors affecting the resection site during LVRS, such as scars or pulmonary nodules. However, none of the included patients had a malignancy. Third limitation is the lack of postoperative CT evaluation of patients to confirm the operation, respectively to reproduce the resection border. The association between recommended zones for removal and finally removed lung areas had to be done by reviewing the operative reports, which may have led to some discrepancy in defining the resection area.

In conclusion, our study suggests that CC CT images allow a precise, less observer-dependent quantitation of distribution of pulmonary emphysema and resection recommendation compared to axial and MPR CT images.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The local ethics committee approved the study (EC-No. 2014-0275), and informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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Supplementary

Table S1 Results of spearman correlation between visual emphysema score of all readers and calculated emphysema amount

Image-type	Location	Spearman ρ	P value
Axial	1	0.48	<0.001
Axial	2	0.18	0.194
Axial	3	0.39	<0.001
MPR	1	0.45	<0.001
MPR	2	0.15	0.596
MPR	3	0.40	<0.001
CC	1	0.39	<0.001
CC	2	0.15	0.679
CC	3	0.40	<0.001

MPR, multiplanar reconstruction; CC, colour-coded; 1, upper zone; 2 middle zone; 3, lower zone.

Table S2 Results of spearman correlation between visual emphysema score for each reader and calculated emphysema amount

Reader	Location	Image type	Spearman ρ	Statistic	P value
1	1	Axial	–0.18	24498.91	1
1	2	Axial	–0.64	34147.17	<0.001
1	3	Axial	–0.29	26808.98	0.43
1	4	Axial	–0.21	25212.2	1
1	5	Axial	–0.42	29527.47	0.025
1	6	Axial	–0.43	29873.99	0.016
1	1	MPR	–0.56	32388.69	<0.001
1	2	MPR	–0.69	35154.75	<0.001
1	3	MPR	–0.28	26585.51	0.518
1	4	MPR	–0.02	21203.65	1
1	5	MPR	–0.21	25236.96	1
1	6	MPR	–0.43	29844.09	0.017
1	1	CC	–0.62	33754.92	<0.001
1	2	CC	–0.62	33758.54	<0.001
1	3	CC	–0.09	22796.74	1
1	4	CC	–0.08	22473.02	1
1	5	CC	–0.18	24644.27	1
1	6	CC	–0.46	30419.63	0.008
2	1	Axial	–0.5	31288.84	0.002
2	2	Axial	–0.68	35015.31	<0.001
2	3	Axial	–0.22	25312.67	1
2	4	Axial	–0.08	22554.7	1
2	5	Axial	–0.42	29582.28	0.024
2	6	Axial	–0.54	32090.78	<0.001
2	1	MPR	–0.55	32187.65	<0.001
2	2	MPR	–0.7	35445.46	<0.001
2	3	MPR	–0.26	26211.97	0.697
2	4	MPR	0.08	19106.2	1
2	5	MPR	–0.34	28003.93	0.142
2	6	MPR	–0.56	32449.89	<0.001
2	1	CC	–0.61	33425.26	<0.001
2	2	CC	–0.57	32618.88	<0.001
2	3	CC	–0.27	26423.82	0.59
2	4	CC	0.09	18898.96	1
2	5	CC	–0.41	29400.57	0.03
2	6	CC	–0.55	32277.25	<0.001
3	1	Axial	–0.49	31091.91	0.003
3	2	Axial	–0.73	36131.37	<0.001
3	3	Axial	–0.16	24229.46	1
3	4	Axial	–0.09	22745.62	1
3	5	Axial	–0.49	30982.09	0.003
3	6	Axial	–0.48	30735.86	0.005
3	1	MPR	–0.43	29718.86	0.02
3	2	MPR	–0.75	36436.97	<0.001
3	3	MPR	0	20829.2	1
3	4	MPR	0	20728.45	1
3	5	MPR	–0.34	27859.54	0.164
3	6	MPR	–0.4	29246.28	0.036
3	1	CC	–0.37	28527.54	0.082
3	2	CC	–0.6	33308.99	<0.001
3	3	CC	–0.11	23103.52	1
3	4	CC	0.06	19656.54	1
3	5	CC	–0.32	27497.17	0.233
3	6	CC	–0.39	28892.66	0.054

MPR, multiplanar reconstruction; CC, colour-coded; 1, upper right zone; 2 upper left zone; 3, middle right zone; 4, lower right zone; 5, lower left zone.