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The Added Value of Minimum Intensity Projection in Cases of Hypersensitivity Pneumonitis

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Abstract

Background: HRCT is the most sensitive examination to characterize the findings of hypersensitivity pneumonitis. High resolution computed tomography scanning is frequently carried out as part of the initial diagnostic assessment of HP.

MinIP images aided in the visualization of some characteristics CT features of HP such as mosaic attenuation, and ground glass opacities by delineating low attenuating areas within mosaic attenuation. It also demonstrated areas of air trapping. MinIP images also showed better visualization of traction bronchiectasis & and bronchiolectasis as well as cysts. However, visualization of other features of HP as ill-defined centrilobular nodules, reticulations, and honeycombing was not aided by MinIP.

Aim of Study: To highlight the key role of high-resolution computed tomography scanning (HRCT scan) with the use of minimum intensity projection (MinIP) reformation in diagnosis of hypersensitivity pneumonitis (HP).

Material and Methods:

- The cross sectional prospective study involved 47 patients (40 female and 7 male) diagnosed as cases of hypersensitivity pneumonitis. Cases were referred from outpatient department of Pulmonology Unit of Kasr Al-Ainy Hospital for follow-up HRCTover a over a period of 10 month from January 2023 to October 2023.
- All patients underwent HRCT chest using 16 channels multi-slice computed tomography (MSCT) scanner in Kasr Al-Ainy hospital.

Results: In this study out of total cases (47), 44.7% of cases showed features of non-fibrotic HP, while 55.3% of cases showed features of fibrotic HP.

The most common HRCT finding seen in this study were mosaic attenuation & ground glass opacities both were seen in 93.6% of cases each. Similarly reticulations which included interlobular & intralobular interstitial thickening was seen in 55.3% of cases. Tractional bronchiectasis & tractional bronchiolectasis was seen in 36.2% of cases and centrilobular nodules was seen in 27.7% of the cases. The least common findings seen were lung cysts and honey combing, both of them were seen in 17% cases each.

Conclusions:

- MinIP clearly delineates the difference in lung attenuation pattern within mosaic attenuation by delineating high attenuating areas such as ground glass opacity with areas of low attenuation such as air trapping. MinIP can be used as alternate for visualization of air trapping, where it's difficult to acquire an expiratory study or when it's unavailable. Similarly, as it can aid in better visualization of the airways, it is very helpful in visualization of tractional bronchiectasis and tractional bronchiolectasis which indicates fibrotic nature of disease.
- However, MinIP is unable to visualize other HRCT findings of HP such as centrilobular nodules & other fibrotic changes such as reticulations & honeycombing. Thus, MinIP should be used as an addition to conventional HRCT images in reaching diagnosis of HP.

Key Words: *Hypersensitivity pneumonitis – HRCT – MinIP.*

Introduction

HYPERSENSITIVITY pneumonitis (HP) is an inflammatory and/or fibrotic condition that affects the small airways and lung parenchyma. It often arises

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List of Abbreviations:

HP : Hypersensitivity pneumonitis.
CT : Computed tomography.
HRCT : High resolution computed tomography.
MINIP : Minimum intensity projection.
WW : Window width.
WL : Window level.
MIP : Maximum intensity projection.

from an immune-mediated response in susceptible individuals triggered by an obvious or covert inhaled antigen **[1,2]**.

HRCT is the most sensitive examination to characterize HP findings and has been advocated as a pivotal instrument for the differential diagnosis of chronic HP with ILDs, especially in clinical scenarios in which the performance of lung biopsy is not possible **[3]**.

The usual computed tomography HRCT findings in HP are small, ill-defined centrilobular nodules, air-trapping, ground-glass opacities, mosaic attenuation and, when there is fibrotic/chronic HP additional lung fibrosis-related HRCT abnormalities can be noticed on top of the findings mentioned above **[2]**.

Multi-planar slab images known as minimum-intensity projection images (MinIP) are produced by showing only the lowest attenuation value along a ray projected through an object and toward the viewer's eye **[4]**.

The MinIP reformation makes it easier to see the characteristics HRCT features of HP, particularly air trapping, which is a crucial component in HP diagnosis. MinIP is also an excellent tool for visualization of tractional bronchiectasis and bronchiolectasis which is a sign denoting fibrotic nature of HP **[5-7]**.

Patients and Methods

Patients:

The cross sectional prospective study involved 47 patients (40 female and 7 male) diagnosed as cases of hypersensitivity pneumonitis. Cases were referred from outpatient department of pulmonology unit of Kasr Al-Ainy hospital for follow-up HRCT.

Inclusion criteria:

- Diagnosed cases of hypersensitivity pneumonitis showing positive radiological features of fibrotic or non-fibrotic HP on follow-up HRCT.

Exclusion criteria:

- CT images that contained significant artifact.
- No significant radiological features suggesting fibrotic or non-fibrotic HP.

Methods:

A- Patient preparation:

All patients underwent clinical assessment which included demographic data (age & gender), exposure to raising birds or other exposures, history of smoking & symptoms including cough, dyspnea.

Protocol of CT techniques:

- All patients underwent HRCT chest using 16 channels multi-slice computed tomography (MSCT) scanner in Kasr Al-Ainy hospital using the parameters as displayed in in table (Table 1).
- All volumetric CT chest assessed at lung window WW 1600 WL -400, HRCT window WW 1000 WL -700, mediastinal window with window width 400 and window level 40.
- Expiratory imaging was done whenever possible.
- Reconstructed images.
- MinIP reformation was performed for corresponding HRCT images.
- Axial, sagittal and coronal HRCT images.
- Axial MIP images.

Table (1): HRCT technique.

	Siemens Scope (CTAWP92544) MSCT
Scout	o 130 Kv o 25 mA o Holding breath
Scan type	Helical
Detector Row	16
Slice Thickness	1.5 mm
Interval	0.75 mm
FOV	320 mm from root of the neck to level of renal arteries.
kV	130
mA	250
Exposure time Per rotation	0.6 s
Total exposure time 9 sec	

Study design:

Cross sectional study.

Data analysis:

- Two radiologists reviewed the MSCT chest images along with the clinical data, laboratory data, and previous radiology reports.
- The cases assessed for findings of fibrotic and non-fibrotic findings.
- Comparing HRCT and MINIP fidnings.

Statistical analysis:

Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Data was summarized using mean, standard deviation, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data.

Results

The patient's age ranged from 27 to 68 years with mean age of 46.57±10.05 years old. The majority of patients were females accounting for 85.1% (n=47) of cases.

History of raising birds was found in 93.6% of patients. All (100%) of the included patients presented with cough while 91.5% patients also had dyspnea. 21% patients had history of smoking.

In this study out of total cases (47), 44.7% of cases showed features of non-fibrotic HP, while 55.3% of cases showed features of fibrotic HP.

Fibrotic HP presented with different signs of fibrosis including reticulations (interlobar & intralobular interstitial thickening), Traction bronchiectasis, bronchiolectasis and honeycombing (Fig. 1).

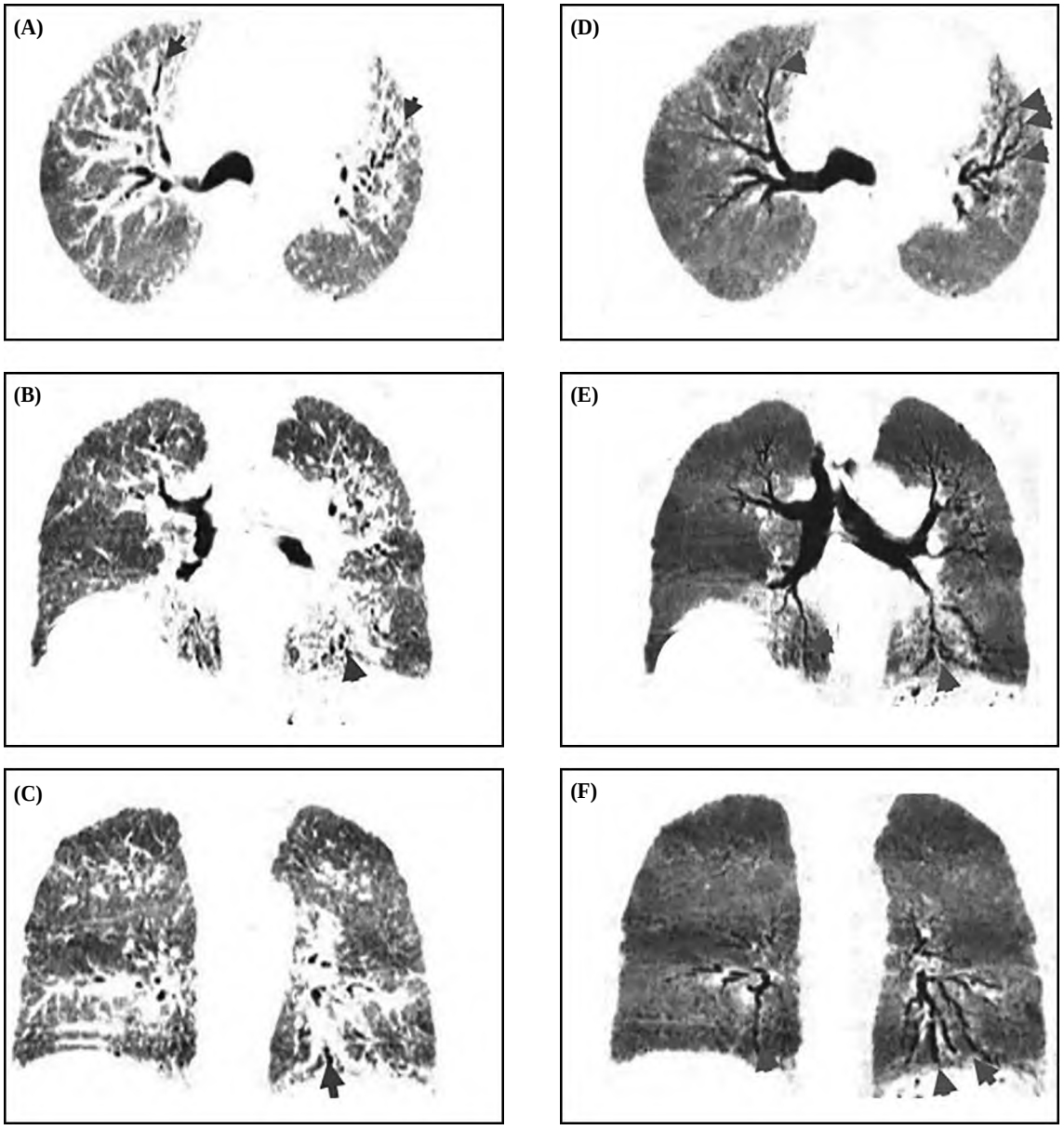

Fig. (1): 44 years female with diagnosis of fibrotic hypersensitivity pneumonitis. HRCT axial and coronal images (A, B & C) shows mosaic attenuation and few tractional bronchiectasis changes (blue arrows). MinIP axial and coronal images (D, E & F) shows additional areas of tractional bronchiectasis and tractional bronchiolectasis changes denoting fibrosis which are more conspicuous in MinIP than in HRCT images.

As shown in Table (2) the most common HRCT finding seen in this study were mosaic attenuation & ground glass opacities both were seen in 93.6% of cases each. Similarly reticulations which included interlobular & intralobular interstitial thickening was seen in 55.3% of cases. Tractional bronchiectasis &tractional bronchiolectasis was seen in 36.2% of cases and centrilobular nodules was seen in 27.7% of the cases. The least common findings seen were lung cysts and honey combing, both of them were seen in 17% cases each.

In this study mosaic attenuation was seen as one of the most common findings and was seen in (44) 93.6% out of total cases (n=47). 75% of cases with mosaic attenuation were better visualized in MinIP than HRCT in these case. While 25% of cases with mosaic attenuation were equally conspicuous in both HRCT and MinIP, (Table 3 & Figs. 2,3).

Table (2): Summary of the main HRCT findings.

HRCT findings	More obvious in HRCT		More obvious in MINIP		Equal in both		Total	
	Count	%	Count	%	Count	%	Count	%
Mosaic attenuation	0	0.0	33	75.0	11	125.0	44	100.0
Bilateral Ground glass opacities	0	0.0	37	84.1	7	15.9	44	100.0
Reticulations (interlobar & intralobular interstitial thickening)	23	88.5	0	0.0	3	11.5	26	100.0
Traction bronchiectasis/bronchiolectasis	0	0.0	17	100.0	0	0.0	17	100.0
Centrilobular nodules	13	100.0	0	0.0	0	0.0	13	100.0
Cysts	0	0.0	7	87.5	1	12.5	8	100.0
Honey Combing	6	5.0	0	0.0	2	25.0	8	100.0

Table (3): Comparison of findings in HRCT & MinIP.

Findings	Total	
	Count	%
Mosaic attenuation	44	93.6
Ground glass opacity	44	93.6
Reticulations (interlobar & intralobular interstitial thickening)	26	55.3
Traction bronchiectasis/bronchiolectasis	17	36.2
Centrilobular nodules	13	27.7
Cysts	8	17.0
Honey Combing	8	17.0

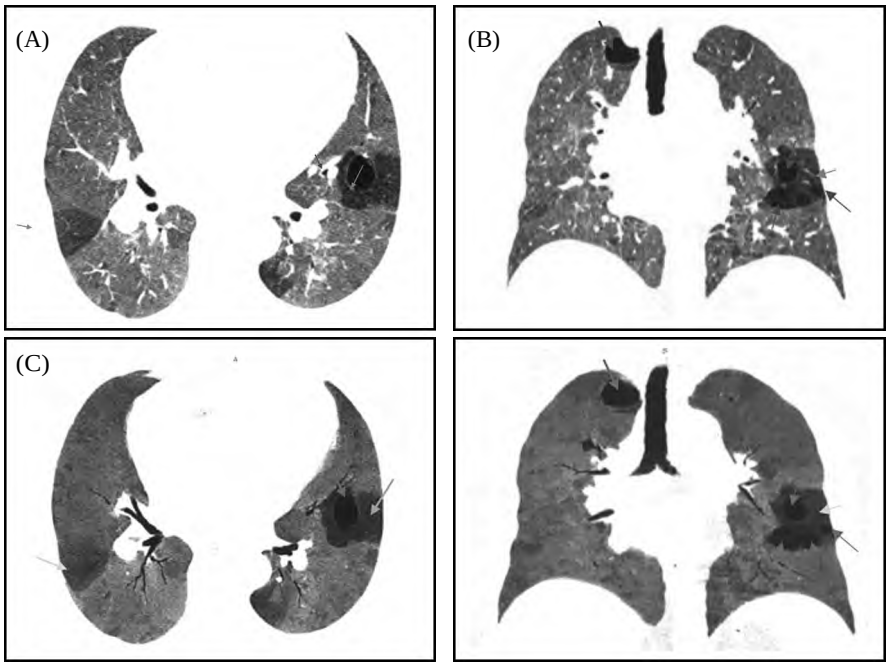

Fig. (2): 58 year female with diagnosis of non-fibrotic hypersensitivity pneumonitis. HRCT axial and coronal images (A & B) shows bilateral diffuse mosaic attenuation comprising areas of high attenuation due to diffuse ground glass opacities and low attenuation areas due to air trapping (orange arrows), also few cysts are seen, few of them are seen within areas of air trapping. MinIP images (C & D) delineates areas of ground glass and air trapping. Cysts lucency is better visualized in MinIP images than HRCT. Also those cysts which are seen within areas of air trapping are also better delineated in MinIP (blue arrows). However cyst wall is not conspicuous in MinIP images.

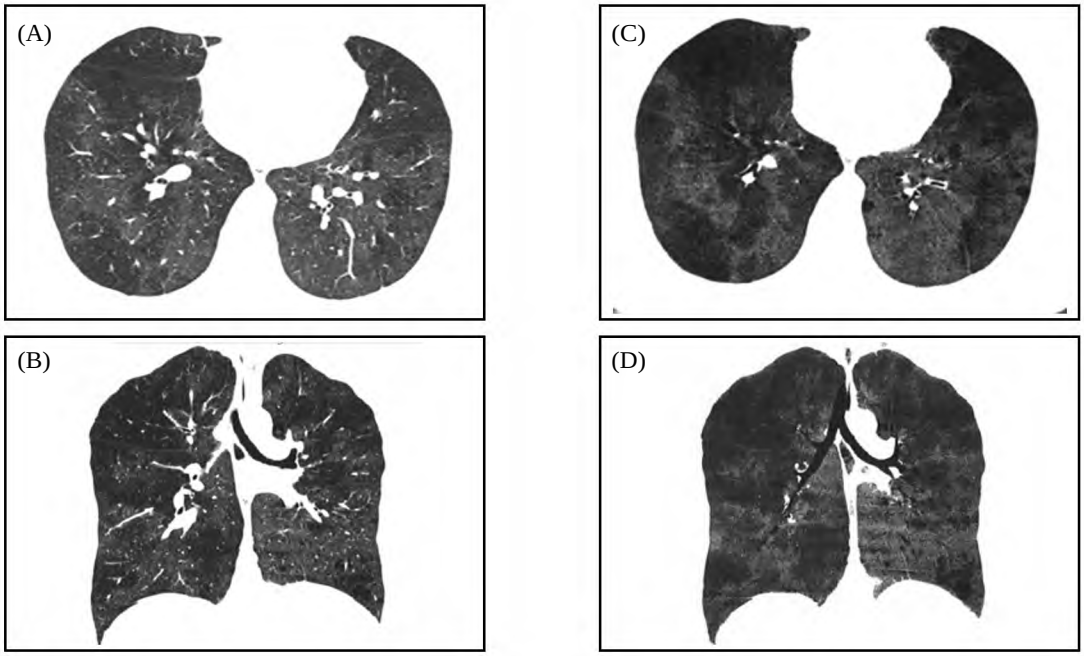

Fig. (3): 32 year female with diagnosis of non-fibrotic hypersensitivity pneumonitis HRCT coronal reformatted images (A & B) shows bilateral patchy ground glass opacities intermingled with areas of low attenuation. MinIP images (C & D) better delineates patchy ground glass opacities (blue arrows).

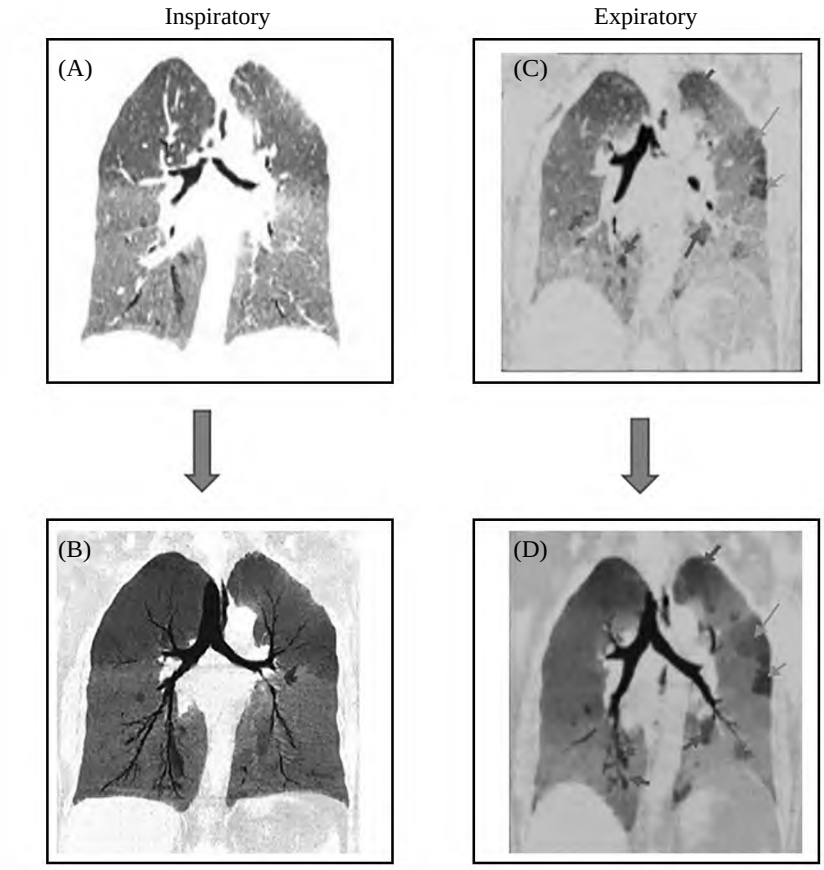

Fig. (4): 53-year female diagnosed with non-fibrotic HP. Inspiratory CT scan with coronal reformation (A) Shows diffuse parenchymal ground glass attenuation without any obvious areas suggesting air trapping. However in corresponding inspiratory MinIP image (B) Areas of hyperlucency are seen suggesting areas of air trapping. Images (C&D) Shows expiratory CT scan with coronal reformation and corresponding MinIP image further delineates and verifies areas of air trapping (blue arrows) which were previous noted, and also adds more areas of areas of air trapping which were not identified in inspiratory MinIP images (orange arrows). The expiratory MinIP (D) Images further delineates the expiratory HRCT images and we can see the areas of air trapping best demonstrated by expiratory MinIP images.

The most common associated HRCT finding was dilated main pulmonary artery which was seen in 38.3% of cases out of total cases (n=47). Similarly pulmonary nodules was seen in 31.9% of cases. Enlarged mediastinal lymph nodes were seen in 23.4% of cases and emphysematous changes were seen in 10.6% of cases.

Discussion

Studies have found that, on the basis of the HRCT pattern, hypersensitivity pneumonitis can be reliably diagnosed in 87%-92% of cases *[8-10]*.

In HRCT images, the key findings of patients diagnosed with HP are presence of centrilobular nodules, ground-glass opacities, air trapping, and mosaic attenuation. The "three-density pattern," a kind of mosaic attenuation that contains areas of ground-glass opacification, lobular areas of low attenuation, and normal lung, has a diagnostic specificity of 93% for HP *[11]*.

The prospective study included 47 patients diagnosed with hypersensitivity pneumonitis, out of which 55.3% were fibrotic HP and 44.7% were non-fibrotic HP. Fibrotic HP presented with signs of fibrosis including reticulations (Interlobar and intralobular interstitial thickening), traction bronchiectasis/bronchiolectasis and honeycombing. Most of the cases were females accounting for 85.1% of total cases. This was consistent with the evidence in literature that indicates higher affection of females with HP *[12]*.

The MINIP changes are enhanced with expiratory scan associated with increased observer confidence and agreement (Fig. 1).

In this study mosaic attenuation was another common HRCT finding which was present in 96.2% of cases. Mosaic attenuation was better visualized in MinIP being more obvious in MinIP in 75% of cases. In this study low attenuation areas present in mosaic attenuation were mainly due to air trapping. Some of these areas of air trapping which were easily missed in HRCT images were delineated in MinIP, and were confirmed in expiratory study done for four of our patients. We found the areas of air trapping seen in MinIP, corresponded to areas of air trapping in expiratory images done for few cases in our study. This demonstrated the role of MinIP in delineating air trapping when expiratory study is not available. This agrees with the study done by Lacout et al., which showed that MinIP can reduce patient irradiation by facilitating the demonstration of air trapping without the requirement for expiratory acquisition. It also agrees with another study done by Sabri et al., which showed better visualization of mosaic attenuation in MinIP and yet another study done by Watadani et al., where MinIP images showed better facility in evaluation of lung diseases presenting with low attenuation. This also agrees with previously stated study by Kauczo and Beigelman-Aubry et al., which showed MinIP was of value in detection of ground-glass attenuation and mosaic perfusion *[6,7,13 -15]*.

In this study all the cases with traction bronchiectasis and traction bronchiolectasis were better delineated in MinIP compared to HRCT images, suggesting MinIP as an excellent tool for visualization of traction bronchiectasis & bronchiolectasis. This was consistent with study done by Sabri et al., in which in which traction bronchiectasis and traction bronchiolectasis resulting from fibrotic changes were better visualized in MinIP than HRCT *[7]*.

Thin-wall cysts are another finding observed in HP and may be related to the partial obstruction of small airways by peribronchiolar lymphocytic infiltrate *[8]*. In this study cyst were present in 17% of cases. 87.5% of which was better seen in MinIP and 12.5% was seen equally obvious in both MinIP and HRCT, suggesting MinIP to be good tool for visualization of cysts. This was in agreement with another study done by Raghu et al., which showed better visualization of cysts in Lymphangiomyelomatosis cases and also found that MinIP could detect smaller cysts that were not seen in the HRCT *[16]*. However, wall of the cyst was not delineated in MinIP.

Centrilobular nodules is most commonly found in subacute forms, but it may also be associated with fibrosis in chronic forms. In this study centrilobular nodules were seen in 27.7% of cases, 100% of which were seen more obvious HRCT than in MinIP. This suggests that there is no role of MinIP for visualization oif centrilobular nodules.

Reticulation results from thickening of the interlobular or intralobular septa/interstitium and appears as several linear opacities that resemble a mesh or a net on HRCT scans. It was clearly delineated in HRCT images, MinIP didn't aid in visualization of reticulations. This was in agreement with study conducted by Sabri et al., in which reticulations was seen less obvious in MinIP than in HRCT *[7]*.

Similarly honey combing is another sign of fibrosis and was seen in cases with fibrotic/chronic HP. MinIP was not informative in visualization of honeycombing rather they were clearly visualized in HRCT images. This is in agreement with study conducted by Sabri et al., where honeycombing was better visualized in HRCT and was poorly detected in MinIP *[7]*.

Conclusions:

In this study, we used MinIP images as a useful additional tool to conventional HRCT images that aids in visualization of various radiological findings of hypersensitivity pneumonitis such as mosaic attenuation, air trapping, ground glass opacity, tractional bronchiectasis & cysts, which

eventually helps in the diagnosis of hypersensitivity pneumonitis.

MinIP clearly delineates the difference in lung attenuation pattern within mosaic attenuation by delineating high attenuating areas such as ground glass opacity with areas of low attenuation such as air trapping. MinIP can be used as an alternate for visualization of air trapping, where it's difficult to acquire an expiratory study or when it's unavailable. Similarly, as it can aid in better visualization of the airways, it is very helpful in visualization of tractional bronchiectasis and tractional bronchiolectasis which indicates fibrotic nature of disease.

However, MinIP is unable to visualize other HRCT findings of HP such as centrilobular nodules & other fibrotic changes such as reticulations & honeycombing. Thus, MinIP should be used as an addition to conventional HRCT images in reaching diagnosis of HP.

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القيمة المضافة لإسقاط الحد الأدنى من الشدة فى حالات الالتهاب الرئوى الناتج عن فرط الحساسية

فى هذه الدراسة، استخدمنا صور الحد الادنى من الشدة كأداة إضافية مفيدة لصور التصوير عالى الدقة التقليدية التي تساعد فى تصور النتائج الإشعاعية المختلفة للالتهاب الرئوى الناتج عن فرط الحساسية مثل التوهين الفسيفسائى، ومحاصرة الهواء، وعاتمة الزجاج الأرضى، وتوسع القصبات الجرية والخراجات، مما يساعد فى النهاية فى تشخيص الالتهاب الرئوى الناتج عن فرط الحساسية.

يحدد صور الحد الادنى من الشدة بوضوح الفرق فى نمط توهين الرئة ضمن التوهين الفسيفسائى عن طريق تحديد مناطق التوهين العالية مثل عاتمة الزجاج الأرضى مع مناطق التوهين المنخفضة مثل محاصرة الهواء. كبديل لتصور محاصرة الهواء، حيث يصعب الحصول على دراسة الزفير أو عندما لا تكون متاحة. وبالمثل، نظرًا لأنه يمكن أن يساعد فى رؤية أفضل للممرات الهوائية، فهو مفيد جدًا فى تصور توسع القصبات الجرّى وتوسع القصبات الجرّى الذى يشير إلى الطبيعة الليفية للمرض.

ومع ذلك انه غير قادر على تصور نتائج التصوير عالى الدقة الأخرى مثل العقيدات المركزية الفصيصية والتغيرات الليفية الأخرى مثل الشبكات وأقراص العسل بالتالى يجب استخدامه كإضافة إلى صور التصوير عالى الدقة التقليدية.