Evaluation of the hilar structures on the lateral chest radiograph with minor degrees of obliquity

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Purpose

Anatomical structures depicted on the lateral chest radiograph have been studied as far back as the mid to late 1900’s (1-9). Bachman et al studied the effect of a mild degree of rotation on the lateral chest radiograph and the appearance of anatomical structures with slight rotation (1). These studies have given an anatomical basis for radiographic findings on the lateral chest radiograph, but there were limitations in these studies, and more thorough investigation is possible with current advancements in technologies, particularly CT reformat images.

One of the limitations is that plain radiographs are 2-dimensional representations of 3-dimensional structures (5). This means the superimposition of various structures may give a false representation of these structures and making it difficult for accurate analysis.

Secondly, the previous studies were conducted by physical rotation of the individuals at the time of taking the chest radiograph. Bachman investigated 10-degree rotation in both right and left anterior oblique as per "acceptable" range of rotation (1). While this showed good comparison between the right anterior oblique to the left anterior oblique rotations, the margin of error in how many degrees an individual was rotated as compared to a different individual may have been significant.

Third, the technologies used at the time these studies were conducted may have contributed to the limitations in accurately viewing structures. X-ray machine, imaging plate, image processing, and monitor has improved tremendously as compared to its quality in the 20th centuries (10,11). This means better resolution and fewer artefacts when viewing lateral chest radiograph which would improve the viewing of the image, thus more accurate analysis of the anatomy can be achieved.

In today's age of multi-slice CT, there has been deskilling in the interpretation of the lateral chest radiograph. This paper illustrates hilar anatomy on the lateral chest radiograph using CT datasets, which can be reformatted to look like a chest radiograph. In 1978, Bachman had demonstrated that the lateral chest radiograph with the right side anterior by 10 degrees unravels hilar structures which improve visualisation and diagnosis (1). The anatomical basis for this is revealed in this paper using 3D volume CT datasets in normal patients.
Methods and materials

A CT work station (Siemens Syngo CT workplace) was used to reformat non-contrast chest CT scans to look like a lateral chest radiograph. The width of 500mm was utilised to cover horizontal span across the chest from one lateral end of skin to the other end for reformatting. Left and right posterior arches of the ribs were superimposed to achieve true lateral position. The chest CT was also reformatted to a lateral chest radiograph with minor degrees of obliquity, specifically right anterior oblique and left anterior oblique by 10 degrees and 20 degrees. These images were reviewed and correlated with the CT scan in axial, sagittal and coronal planes.
Results

Pulmonary vessels

Analysis of the left and right pulmonary arteries show that the right pulmonary artery is positioned slightly anterior and inferior to the left pulmonary artery with slight superimposition on the true lateral position. Therefore, with slight left anterior oblique rotation, the right and left pulmonary arteries are superimposed further and it becomes very difficult to distinguish the two structures. Refer to figure 1 for location of left and right pulmonary arteries at true lateral position.

Separation of the left and right pulmonary arteries is seen in the right anterior oblique rotation even from minor rotations at 10 degrees. This becomes more distinct with increasing rotational angle. Refer to table 1 for descriptive overview of left and right pulmonary artery visualisation at different angles of rotations.

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Right pulmonary artery</th>
<th>Left pulmonary artery</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAO 20</td>
<td>Partly superimposed, posterior to LPA</td>
<td>Partly superimposed, anterior to RPA</td>
</tr>
<tr>
<td>LAO 10</td>
<td>Mostly superimposed, slightly anterior</td>
<td>Mostly superimposed, slightly posterior</td>
</tr>
<tr>
<td>TL</td>
<td>Visualised but partly superimposed</td>
<td>Reduced visibility due to superimposition</td>
</tr>
<tr>
<td>RAO 10</td>
<td>Easily visualised</td>
<td>Visualised but not as clearly as RPA</td>
</tr>
<tr>
<td>RAO 20</td>
<td>Easily visualised, distinct separation</td>
<td>Easily visualised, distinct separation</td>
</tr>
</tbody>
</table>

Table 1 - Visualisation of pulmonary arteries at different angles of rotation

Trachea and upper lobe bronchi

The trachea is viewed side-on at the true lateral position. Right upper lobe bronchus is seen superior and anterior to left upper lobe bronchus in this position. Left upper lobe bronchus is more easily visualised than right upper lobe bronchus in true lateral position. Refer to figure 2 and 3 for location of left and right upper lobe bronchi at true lateral position. As the rotation increases, the trachea and the bronchi also rotate. This allows for visualisation of carina as well as separation of left and right upper lobe bronchi with
increasing rotation. It is much more difficult to visualise the bronchial structures on the left anterior oblique than in the right anterior oblique due to superimposed hilar structures, as well as increasing superimposition between the left and right upper lobe bronchi. However, as the left anterior oblique rotation increases past a certain point, separation between the upper lobe bronchi is seen. The posterior tracheal band can be visualised on left anterior oblique but not on right anterior oblique. The likely reason for this is due to increasing superimposition on the posterior side of trachea which increases the radiopacity. Figure 4 demonstrates trachea and posterior tracheal band on true lateral position. Refer to table 2 for descriptive overview of left upper lobe bronchus, right upper lobe bronchus and posterior tracheal band visualisation at different angles of rotations. Refer to figure 5 for annotated diagram at 20 degrees, 10 degrees left and right oblique rotation and true lateral position. Figure 6 and 7 demonstrates the unravelling of hilar structures with the left anterior oblique and right anterior oblique rotations respectively.

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Right upper lobe bronchus</th>
<th>Left upper lobe bronchus</th>
<th>Posterior tracheal band</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAO 20</td>
<td>Posterior to L bronchus</td>
<td>Anterior to R bronchus</td>
<td>Visible</td>
</tr>
<tr>
<td>LAO 10</td>
<td>Mostly superimposed</td>
<td>Mostly superimposed</td>
<td>Visible</td>
</tr>
<tr>
<td>TL</td>
<td>Partly superimposed</td>
<td>Partly superimposed</td>
<td>Partly visible</td>
</tr>
<tr>
<td>RAO 10</td>
<td>Visible, partly separated</td>
<td>Visible, partly separated</td>
<td>Not visible</td>
</tr>
<tr>
<td>RAO 20</td>
<td>Visible extending down</td>
<td>Clearly visible, partly separated</td>
<td>Not visible</td>
</tr>
</tbody>
</table>

Table 2 - Visualisation of bronchi and posterior tracheal band at different angles of rotation

The implications of these findings are that right anterior oblique position unravels hilar structures such as pulmonary vessels and upper lobe bronchi which may show mass or other pathology in those areas which may otherwise be hidden in conventional lateral chest radiograph. Further research on visualisation of other structures would be helpful for future study, but the findings of this research indicates using mild right anterior oblique lateral chest radiograph instead of conventional lateral chest radiograph or as an addition may be beneficial in improving the diagnostic quality for radiologists.

Limitations
The methodology in this study was devised to minimise the variables that may affect the result, but some limitations still exist in computing and data collection process.

Firstly, CT manipulated lateral chest radiograph would be much less subjective to divergent beam than that of the conventional lateral chest radiograph. Since the CT scan is taken at all angles around the patient with a much smaller distance between the patient and the image receptor as compared to lateral chest radiograph, there is less divergent beam (5,12). This would mean less magnification of structures which can have slight differences in the size of certain structures when comparing CT manipulated lateral chest radiograph to the conventional lateral chest radiograph.

Second, the CT chest data was collected from patients who have relatively normal anatomy to represent the majority of the population’s anatomy. In reality, there is a minority group of the population who has different anatomical structures than the majority of the population. In these instances, there may be some differences in the visualisation of certain anatomical structures as compared to what has been investigated in this study.

Third, the rotation was measured using a protractor on a CT workstation. This means there may have been slight human error in rotational angle. Having said this, the rotation measured this way would have a much smaller margin of error as compared to adjusting rotation on the actual patient if the study was conducted solely on conventional lateral chest x-ray given differences in body structure between patients and positioning by different personnel would be contributing variables.
**Fig. 1:** Right and left pulmonary artery on lateral view are indicated by the blue circle.

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Fig. 2: Right upper lobe bronchus on lateral view is indicated by the red circle.

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**Fig. 3:** Left upper lobe bronchus on lateral view is indicated by the red circle.

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**Fig. 4:** Lateral view where trachea is indicated by the red rectangle and posterior tracheal band is indicated by the blue arrow.

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**Fig. 5:** Left anterior oblique to right anterior oblique rotation with structures indicated by arrows.

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Fig. 6: Images from left to right showing true lateral position to left anterior oblique by 10 degrees.

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Fig. 7: Images from left to right showing true lateral position to right anterior oblique by 10 degrees.

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Conclusion

In conclusion, this paper may help in improving the skills of radiologists in the interpretation of the lateral chest radiograph. It illustrates the radiographic anatomy using CT scan reformat images to mimic a lateral chest radiograph. The effect of minor degrees of obliquity on the visualisation of hilar structures is also demonstrated.
Personal information

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References


