HRCT in CHILDREN

strengths and weaknesses in practice:

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HRCT IN CHILDREN-emphasis on INTERSTITIAL DISEASES strengths and weaknesses in practice:

AIM

The aim of this talk is to discuss the role of thin slice high resolution CT in paediatric practice and to describe the various means by which these images can be acquired to a satisfactory [diagnostic] level in routine paediatric practice. It is also to highlight the utility of HRCT in paediatric practice to enable the various patterns of disease processes to be understood.

The main role for HRCT is in the diagnosis and follow up of diffuse airways and interstitial lung diseases in children.

We will focus on the utility of HRCT in diagnosis of paediatric diffuse interstitial Lung disease [DILD] and the inherent strengths and weakness within the ultimate choices made to acquire images. We will emphasise and illustrate the specific conditions for which HRCT provides a powerful diagnostic tool.

Background

The role of HRCT in paediatric interstitial lung disease is evolving. In adults, the diagnostic accuracy of HRCT has led to a decrease in the number of lung biopsies performed. As the chest radiograph is often a non-specific tool, HRCT has been shown in adults and children to increase the accuracy at diagnosis of diffuse lung disease.
The trade off in sensitivity and specificity of HRCT over CXR is related to radiation dose which is significantly higher with conventional spiral or volumetric CT. As children are more radiosensitive than adults and have a longer life span in which to develop radiation-induced disease, great care must be taken with the use of radiation and the HRCT protocol should be designed to provide the best image quality at the lowest possible radiation dose.[1 ] For conventional non volumetric CT it has been shown that as compared to a 180-mAs technique, a lower-dose HRCT technique results in a significant dose reduction of 72% for 50mAs and 80% for 34mAs; good quality images were obtained with 50mAs in uncooperative children and with 34mAs in cooperative children and young adult patients [2]. Low dose HRCT has been reported to have a radiation dose as low as that required for several chest radiographs [3]. The use of even lower doses in children ie the use of 25mA and 1-second scan time [4,5] has been reported.

The histospecific accuracy of HRCT compared with chest radiographs in making a correct first choice diagnosis in an adult population with diffuse lung disease ranges from 46-75% for HRCT and 38 to 63% for chest radiographs [6,7,8]. HRCT has a reported diagnostic accuracy of 56% for a confident first choice diagnosis in one series of 20 children with interstitial lung disease [9]. This is comparable to a more recent series of 20 children with biopsy proven interstitial lung disease from a single institution [10]. A correct first choice diagnosis was made in 61% of the cases on HRCT compared with 34% on chest radiographs.

The diseases that were correctly diagnosed on HRCT with a high degree of confidence were alveolar proteinosis, pulmonary lymphangiectasia and idiopathic pulmonary haemosiderosis. Differentiation between Nonspecific interstitial pneumonitis (NSIP), Desquamative Interstitial Pneumonitis (DIP and Lymphocytic interstitial pneumonitis (LIP) was, however, less reliable.
There are several pitfalls in the interpretation of HRCT in children. One of the most important is in distinguishing diffuse ground glass infiltration from increased lung attenuation resulting from a suboptimal inspiration. In the upper zones, the position of the posterior tracheal membrane is helpful in distinguishing between the two. The posterior tracheal membrane is convex outwards in inspiration, and appears horizontal or slightly concave on expiration.

The other difficulty that may be encountered is in determining which areas of the lung are abnormal when an investigation reveals widespread ‘mosaic’ pattern of lung attenuation. Deciding on whether the areas of diminished attenuation represent, for example, small airways disease or the areas of increased attenuation (ground glass opacity) represent diffuse infiltration can be challenging. Although expiratory images may be helpful, obtaining images at known phases of respiration is not always achievable in children unless GA and controlled ventilation techniques are used. Use of lateral decubitus imaging CT with the dependent lung simulating expiration is important.

In this way the non dependent lung can also be reliably assessed in apparent inspiration.

**MODE OF ACQUISITION OF HIGH RESOLUTION DATA-CHOICES**

At the present time there are 2 alternatives methods for acquiring high resolution data of lung parenchyma each having inherent strengths and weaknesses.

The ultimate goal is acquisition of diagnostic quality images of lung parenchyma at the lowest possible radiation dose achievable [ALARA principle].

**Methods available at the current time include**
1] VOLUMETRIC DATA ACQUISITION

Acquisition of a thin collimation [eg 0.75 mm ‘Combiscan’ on a 16 slice MDCT scanner] volumetric dataset enables the whole lung volume to be imaged and high resolution [bony algorithm] post processing to optimise visualisation of lung parenchyma viewed at appropriate window levels and widths. It is vital that the images are reconstructed on a high spatial resolution algorithm and displayed with a wide window setting, at a width of 1500 Hounsfield units (HU) and at a level of -500 HU. Filters B60f rather than smooth soft tissue filters [B30f] should be used for image reconstruction.

PRINCIPLES OF VOLUMETRIC DATA ACQUISITION

The development of volumetric data acquisition has significantly enhanced 2D and 3D computed-tomographic (CT) imaging. Volume rendering techniques are now widespread with the development of new, fast and user-friendly workstations.

One of the main advantages to this technique over conventional single slice acquisition is that a single breath-hold volume acquisition is sufficient to render good quality imaging of the whole tracheobronchial tree. The implications of this is that [on average] a 5 second single acquisition results in a complete [usually diagnostic] dataset. This may be important in younger children who are unco-operative as only a single breathhold is required for acquisition of the whole dataset, or if this is not possible quite breathing can be allowed with smaller more predictable respiratory excursions resulting in minimal image degradation.

Alternatively some authors advocate General anaesthesia or deep sedation with controlled ventilation techniques where a face mask forces an excellent inspiratory manoeuvre and
technically exquisite images [which are sometimes important particularly when serially imaging children in the follow up of airways disease eg Cystic fibrosis, undergoing experimental therapy-11].

Additionally, HRCT and volumetric CT of the chest have been shown to detect regional CF lung changes prior to development of global changes in the pulmonary function measurements (12) ie are a more sensitive means for investigating early parenchymal disease in CF.

By acquiring multiple sequences simultaneously, motion artifacts are decreased, shorter data acquisition times, greater coverage, and improved sharpness of images can be achieved. Also when necessary acquisition of isotropic datasets provides the opportunity to reconstruct images in any desired orientation. (13).

Whilst images and reconstructions are attractive and 3D results are praised by the clinicians, axial images remain the main diagnostic tool for radiologists due to their accuracy derived from maximal spatial resolution.(14). Referral to axial images is advised as the main means to exclude artifacts. Consequently, the application of 3D rendering techniques should ideally be reserved for selected cases when specific clinical questions are desired (14,15).

There are however some limitations in axial imaging of the airway: including the large number of images that are generated, the difficulty demonstrating and efficiently representing the structures oblique or parallel to the axial plane and those that develop or extend into multiple planes. 3D rendering can overcome such imperfections in the acquisition of the original axial data (14;15).
The main issue regarding volumetric CT over conventional HRCT is the significant increase in dose which is variable dependent on the various parameters used in acquisition [kV, mA etc] see table 1 for in house MDCT vs conventional HRCT parameters/protocols.

2 Conventional single slice HRCT acquisition

With single slice CT scanners is well established that the use of low dose [50mA, 0.75s] limited [1mm slices every 15-20mm] HRCT in inspiration with 3 expiratory supplementary scans allowed accurate assessment of the presence and extent of diffuse lung disease at a dose equivalent to approximately 10 chest radiographs [1]. Images are reconstructed on a high spatial resolution algorithm and displayed with a wide window setting, at a width of 1500 Hounsfield units (HU) and at a level of -500 HU. If a child is unable to breath-hold, the scans can be performed during quiet breathing and decubitus scans replace expiratory scans (the dependent lung behaving as the “expiratory lung”).

HRCT features of Diffuse Interstitial lung disease.

The classification of DILD is complex and a simplified version will be discussed with specific illustrations from examples listed below.

The Idiopathic Interstitial Pneumonias

Connective Tissue Disorders.

Pulmonary Alveolar Proteinosis [PAP].

Congenital Lymphangiectasia/Diffuse Pulmonary Lymphangiomatosis
**Idiopathic Pulmonary Haemosiderosis (IPH).**

**Langerhan’s Cell Histiocytosis (LCH).**

**Aspiration Pneumonitis**

**Depositional lung diseases**

**Lipid storage diseases**

**Conclusion**

HRCT is an invaluable tool in the investigation of children with diffuse airways and interstitial lung disease. It is important that the radiologist has an understanding of the role of CT in diagnosis and follow up, the various modes of image acquisition and their relative strengths and weaknesses and the various pearls and pitfalls encountered in acquisition of low dose diagnostic images.
### LEGENDS

### TABLES

#### TABLE 1a

In house MDCT [16 slice] vs conventional HRCT parameters/protocols.

<table>
<thead>
<tr>
<th>Volume 1.5mm</th>
<th>Effective dose mSv</th>
<th>Combi 0.75/0.75mm</th>
<th>HRCT 1/10mm</th>
<th>CTA 0.75/0.6mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>&lt; 15 kg.</td>
<td>0.7 7</td>
<td>0.90</td>
<td>0.9</td>
<td>1.05</td>
</tr>
<tr>
<td>&lt; 25 kg.</td>
<td>0.9 3</td>
<td>1.09</td>
<td>1.13</td>
<td>1.31</td>
</tr>
<tr>
<td>&lt; 35 kg.</td>
<td>1.3 4</td>
<td>1.56</td>
<td>1.58</td>
<td>1.84</td>
</tr>
<tr>
<td>&lt; 45 kg.</td>
<td>2.1 1</td>
<td>2.46</td>
<td>2.48</td>
<td>2.89</td>
</tr>
</tbody>
</table>

Dose calculated using: Child phantom, scan range of 19cm, 100 kVp
Annual Background UK 2.5 mSv : Norway 9mSv.
Fig 1b single slice scanner data acquisition helical pitch variation versus single HRCT acquisition vs CXR dose equivalents.

<table>
<thead>
<tr>
<th>Method</th>
<th>Pitch</th>
<th>Ratio [CXR equivalent]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Helical CT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single slice</td>
<td>Pitch 1</td>
<td>7.25mSv 145</td>
</tr>
<tr>
<td>150mAs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pitch 1</td>
<td>3.1</td>
</tr>
<tr>
<td>75</td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>150</td>
<td>Pitch 2</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>62</td>
</tr>
<tr>
<td><strong>HRCT</strong></td>
<td>1/15mm</td>
<td>0.35mSv 7</td>
</tr>
<tr>
<td>50 mAs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CXR</strong></td>
<td></td>
<td>0.05mSv 1</td>
</tr>
</tbody>
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REFERENCES


