How to Deal With Breathing Motion Artefact and Atelectasis in Pediatric Chest CT

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Chest CT in Young Children

- MOTION (patient and breathing) and ATELECTASIS are two of the largest contributors to poor image quality in chest CT in children.
- Current Dual-source multidetector CT permits ultrafast high-pitch sub second examinations potentially eliminating the need for breath-hold and GA.
- Decreased need for CT sedation results in reduced scheduling complexity, cost and morbidity.
- Sedation/anesthesia may still be required for high quality detailed lung parenchymal evaluation in young or uncooperative children.
- Associated atelectasis is a common and important quality issue that produces a substantial risk of missed or misinterpreted findings and additional radiation exposure if repeat imaging is needed.
- Traditional repeat methods such as prone or decubitus scans are relatively unpredictable.
CT 4/4/14 (flash)
GA with facemask

2.5yo - systemic JIA
thrashing, inconsolable
parents request GA

CT 5/9/14 (flash)
GA intubation/recruitment
GA with intubation + recruitment and breath-hold protocol

- Use of a tight fitting face mask during induction and IV placement, peak inspiratory pressures 20-25cm H$_2$O, PEEP 6. Do not use 100% O$_2$
- Prompt intubation with an appropriately sized cuffed ETT
- Alveolar recruitment: 10-12 breaths at 38 - 40/6 PIP/PEEP
- Inspiratory breath-hold at 25-30cm H$_2$O for scan
- Recruitment breaths repeated before each scan phase

15 month boy with Cystic Fibrosis

Volumetric inspiratory/expiratory 1mm 100kVp 35 mAs

Inspiratory

Expiratory
### QUALITY

- 70% of cases with intubate/recruit protocol rated very good to excellent vs 24% of nonprotocol scans

<table>
<thead>
<tr>
<th>QUALITY PROTOCOL</th>
<th>POOR</th>
<th>SATISFACTORY</th>
<th>GOOD</th>
<th>VERY GOOD</th>
<th>EXCELLENT</th>
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<tbody>
<tr>
<td><strong>N = 56</strong></td>
<td>4(7%)</td>
<td>2(4%)</td>
<td>11(20%)</td>
<td>30(54%)</td>
<td>9(16%)</td>
</tr>
<tr>
<td><strong>Non protocol</strong></td>
<td>19(27%)</td>
<td>21(30%)</td>
<td>13(19%)</td>
<td>15(21%)</td>
<td>2(3%)</td>
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<tr>
<td><strong>N = 70</strong></td>
<td>*</td>
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<td><strong>P&lt;0.001</strong></td>
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*p<=0.05

### Atelectasis

- 48% of protocol cases had no or minimal atelectasis
- 51% of nonprotocol scans had segmental or greater atelectasis

<table>
<thead>
<tr>
<th>ATELECTASIS</th>
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<th>Non-Protocol</th>
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<td>N = 56</td>
<td>Repeat = 0</td>
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<tr>
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<th>MINIMAL</th>
<th>SUBSEGMENTAL</th>
<th>SEGMENTAL</th>
<th>MULTISEGMENTAL OR LOBAR</th>
<th>WHOLE LUNG</th>
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<tbody>
<tr>
<td>12 (21%)</td>
<td>15 (27%)</td>
<td>16 (29%)</td>
<td>5 (9%)</td>
<td>8 (14%)</td>
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<td>4 (6%)</td>
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<td>17 (24%)</td>
<td>8 (11%)</td>
<td>28 (40%)</td>
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* p < 0.05

No adverse events observed or reported in any cases

Several children with LMA GA had marked gastric distension

21 cases vs 8 controls that were studied in detail had no clinically or statistically significant differences noted for mean heart rate, respiratory rate, oxygen saturation and mean arterial blood pressure measurements

During lung recruitment there was a mean (SD) tidal volume (Vt) of 487ml (232.9ml) or 35ml/kg (14.0ml/kg) (normal resting value 12ml/kg) and a mean (SD) end tidal CO₂ value of 24mm Hg (6.5mm Hg) (normal 30–45mmHg).

Stable blood pressure responses and no significant cardiovascular compromise during recruitment and inspiratory breath–holds despite the short term increased inspiratory pressures, hyperventilation, and hypocapnia (used for apneic breathhold) during these maneuvers.

3yo F with Recurrent Pneumonia
CECT with LMA/recruitment – repeated same day after intubation and recruitment

80kVp 80mAs 2mm
3 month old girl with Hepatoblastoma
Contrast enhanced spiral chest CT
2mm, 80kVp, 75mAs

Subsegmental atelectasis upper lobes
(early study – 32cm H2O PIP)
3yr old boy with hepatoblastoma
- Initial scan with low ETT and inadequate PIP
- Repeated after repositioning of ETT and lung recruitment at higher pressures
Conclusions

- A standardized anesthesia lung recruitment protocol provides safe, effective and consistent lung inflation and high quality CT images.
- Key protocol features included continuous PEEP(6), prompt intubation, cuffed ETT & effective repeated lung recruitment (38–40cm H2O PIP).
- Individual anesthesiologist efforts were unreliable.
Techniques used to promote non-sedated CT in children

- Child life personnel and technologists/nurses give careful patient and parent education and preparation
- CT models and toys
- Parental presence in the scanner
- Distraction techniques: music, light, decorations
- Feed, wrap and scan
- Ultrafast scanning technique
GA with intubation + recruitment + breath-hold  
Score: 5,0,0

GA without breath-hold  
Score: 1,4,1

Free Breathing without anesthesia  
Score: 4,0,1

3yo - germ cell tumor

13 mo – evaluate for lung abnormality

3yo - hepatoblastoma
1yo with recurrent pneumonia

GA NONBH

REPEAT GA ETT BH
Ultrafast pediatric chest CT: comparison of free breathing/breath-hold imaging with and without anesthesia

N=54

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2yo with Burkitt’s Lymphoma

1/29/2015
PET CT

3/11/2015
Non GA no BH
1 month old infant with RML CLE FLASH MODE CTA
No anesthesia, no breath hold

80 kVp, 1 mm
CTDI .82
DLP14
no SAFIRE

80 kVp, 1 mm
SAFIRE 2

80 kVp, 1 mm
SAFIRE 3
CONCLUSIONS

- free breathing ultra-fast pediatric chest CT without anesthesia does not significantly compromise image quality, suggesting anesthesia may not be necessary in many small patients

- If anesthesia is required, intubation with recruitment and breath-hold is optimal

- Non intubated, non breath-hold anesthesia is the least desirable method