

가 (Virtual Bronchoscopy): (parameter)

1

2

: 가 (virtual bronchoscopy, VB)
가 , helical

CT pitch가 3mm/1, 3mm/1.5, 5mm/1 ,
1mm, 1.5mm, 2mm VB
, VB (threshold) -800HU -200HU
, pitch, ,

: VB % ,

1) pitch가 3mm/1 78.9%, 3mm/1.5 77.5%, 5mm/1 73.7% ;
2) 1mm 77.9%, 1.5mm 76.9%, 2mm 75.1%; 3) 가
-800/-700/-600/-500/-400/-300/-200 HU 86.2%/83.4%/80.4%/77.0%/ 74.8% / 70.2% /
64.5%; 4)
23mm 85.6%, 17mm 75.0% ,
11mm 69.3% .

: VB ,
pitch, ,
가 .

가 (Virtual bronchoscopy, VB) , VB
(helical CT) , VB 가
(volumetric) CT , CT
3
(1,2). VB

scan ,
100 kg polyethylene glycol 400,
95% ethyl alcohol, 40% formalin, 50%, 25%, 10%
15%

(1,3,4). VB
가 3 VB
HU가 177-199 , 가
25cm H₂O
(7).

(5,6). VB 1mm
(8mm 4 , 10mm 1)

가

CT CT

1998 11 17

1999 3 8

(Fig. 1).

CT , VB
GE HiSpeed Advantage (GE Medical
System, Milwaukee, WI, U.S.A.) , 9cm
pitch 3mm/1, 3mm/1.5, 5mm/1 3
scan 120kVp, 200mAs, standard al-
gorithm 3가 CT
1mm, 1.5mm, 2mm
9가 volumetric CT . CT
Advantage Windows Workstation , Navigator
software version 2.0.4 S (General Electric) 9가
VB . VB shaded-surface
soft tissue algorithm .

가
5 10mm
1 8mm
1 8mm 1 ,
3 VB
pitch,
9가 VB , VB (isosurface thresh-
old) -800, -700, -600, -500, -400, -300, -200HU 가
63가 CT 가
cursor , VB
% .

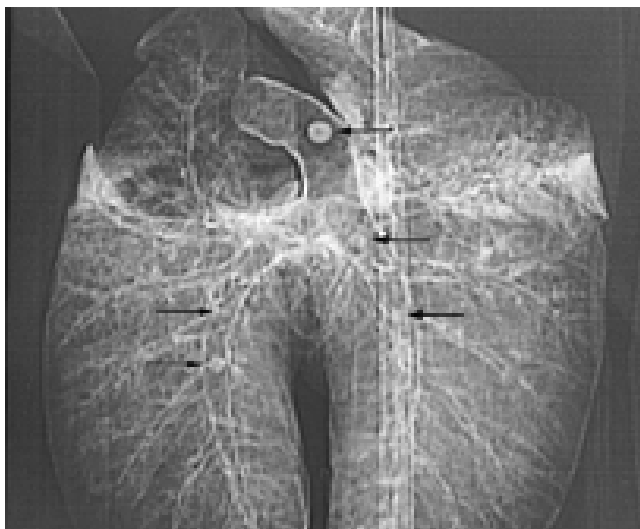


Fig.1. CT scanogram of fixed and inflated pig lung. Five spherical plastic beads (arrows) were randomly placed in trachea and bronchi.

: 가
CT 가
23mm, 17mm, 가 11mm .
VB 가
3 , pitch, 189가 (63가
가 1) pitch;
2) ; 3) ; 4) VB
189가
pitch
(1mm, 1.5mm, 2mm), (-800HU -
-200HU) (23mm, 17 mm,
11mm) , 3mm/ pitch 1 100%
- 61% (78.9%) , 3mm/pitch 1.5
96% - 45% (77.5%), 5mm/ pitch 1 100% -
46% (73.7%) 가 pitch가
가 (Table 1, Fig. 2).
pitch (3mm/1, 3mm/1.5, 5mm/1), (-800HU -
-200HU) (23mm, 17 mm,
11mm) , 1 mm 100% - 45%

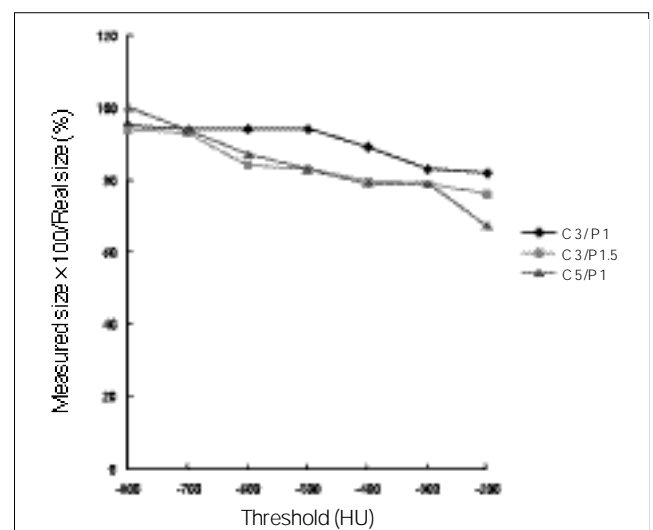


Fig.2. Graph showing effect of varying collimation, pitch and isosurface threshold on measured size of lesion on VB (1mm-reconstruction, lesion in the trachea). C : collimation (mm), P : pitch

(77.9%), 1.5mm 96% - 49% (76.9%), 2mm
98% - 46% (75.1%)
가 (Table 2, Fig. 3).

pitch (3mm/1, 3mm/1.5, 5mm/1), (1mm, 1.5mm, 2mm) (23mm, 17mm, 11mm)
가 -800, -700, -600, -500, -400, -300, -200 HU
100% - 71% (86.2%), 100% - 70% (83.4%), 94% - 69% (80.4%), 94% - 66% (77.0%), 89% - 65% (74.8%), 83-58% (70.2%), 82% - 45% (64.5%)
가 (Table 3, Fig. 2 - 5).

pitch (3mm/1, 3mm/1.5, 5mm/1), (1mm, 1.5mm, 2mm), (-800HU - -200HU), 23mm 98% - 67% (85.6%), 17mm 100% - 59% (75.0%), 11mm 85% - 45% (69.3%)
가 (Table 4, Fig. 5,6).

CT computer graphic CT
VB 가 가 . 가
CT

3

(8). VB

3

voxel
(ray-tracing) algorithm
, screen ray

voxel 가 3 (8,9).
가 100-300 MB
computer workstation

Table 1. Ranges of Measured Lesion Size Compared to Real Size with Changes of Collimation & Pitch

Collimation & pitch	Measured size \times 100/ Real size (%)
3mm/pitch 1	100% - 61% (78.9%)
3mm/pitch 1.5	96% - 45% (77.5%)
5mm/pitch 1	100% - 46% (73.7%)

Table 2. Ranges of Measured Lesion Size Compared to Real Size with Changes of Reconstruction Interval

Reconstruction	Measured size \times 100/ Real size (%)
1mm	100% - 45% (77.9%)
1.5mm	96% - 49% (76.9%)
2mm	98% - 46% (75.1%)

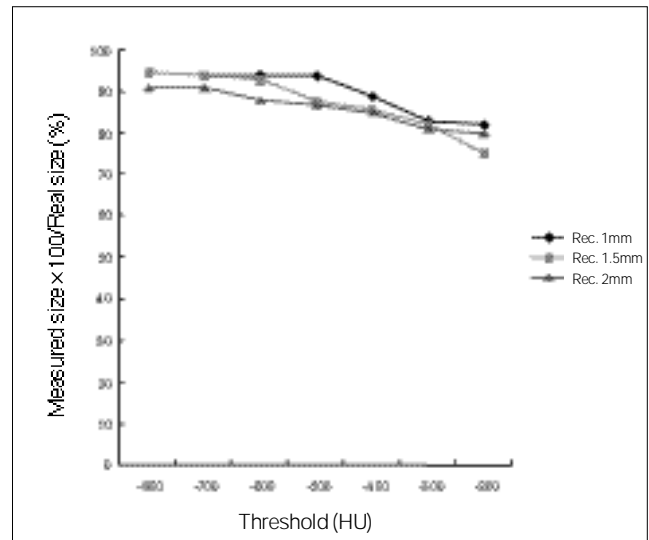


Fig. 3. Graph showing effect of varying reconstruction interval and threshold on measured size of lesion on VB (3mm-collimation, pitch 1, lesion in trachea). Rec. : reconstruction interval

software가

VB

brachytherapy,

가
(1,3,4). VB가

Table3. Ranges of Measured Lesion Size Compared to Real Size with Changes of Threshold

Threshold (HU)	Measured size \times 100/ Real size (%)
- 800	100% - 71% (86.2%)
- 700	100% - 70% (83.4%)
- 600	94% - 69% (80.4%)
- 500	94% - 66% (77.0%)
- 400	89% - 65% (74.8%)
- 300	83% - 58% (70.2%)
- 200	82% - 45% (64.5%)

Table4. Ranges of Measured Lesion Size Compared to Real Size with Changes of Luminal Diameter of Lesion Location

Luminal Diameter	Measured size \times 100/ Real size (%)
23mm	98% - 67% (85.6%)
17mm	100% - 59% (75.0%)
11mm	85% - 45% (69.3%)

: 가

CT , VB 가 가 (Fig. 2-5), 23mm 3-5mm, pitch 1-1.5, 가 -800 HU 0-11% -200 HU 18-34% 가 -500 HU -800 HU , pitch, 23-11 mm 가 -800 HU 0-29% , -200 HU 18-55% (Table 3), 23mm

VB 가 (5,6). 가 -500 HU가 (5) 가 -500 HU 가 -700 10-40% CT VB pitch 가

-400 HU

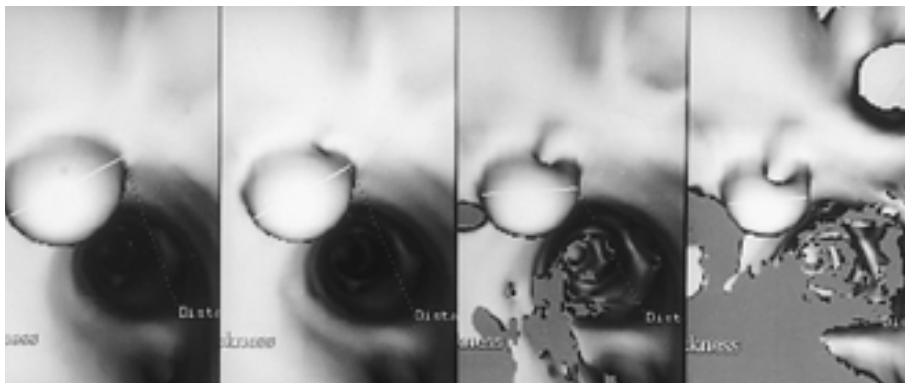


Fig. 4. CT virtual bronchoscopy of simulated endobronchial lesion showing effect of choice of isosurface threshold on size of lesion. Real size of lesion is 8mm. From left to right, thresholds are -800, -600, -400, and -200HU. As threshold decreases, size of simulated endobronchial lesion increases.

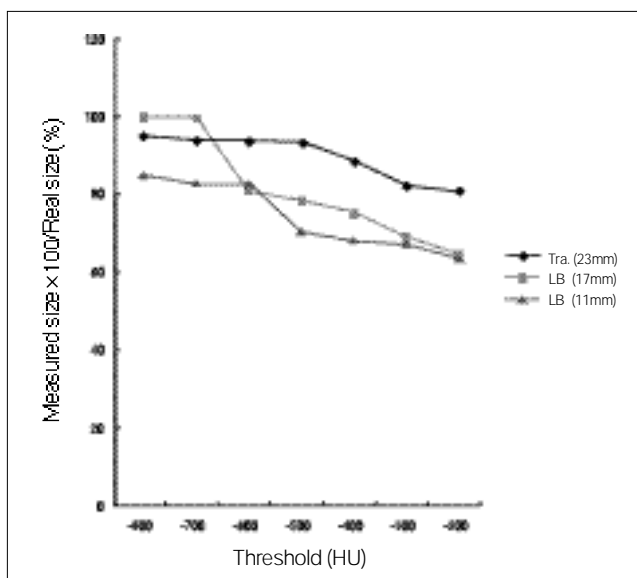


Fig. 5. Graph showing effect of varying luminal diameter of lesion location and isosurface threshold on measured size of lesion on VB (3-mm collimation, pitch 1, 1 mm-reconstruction). Tra. : trachea, LB : left main bronchus, () : luminal diameter

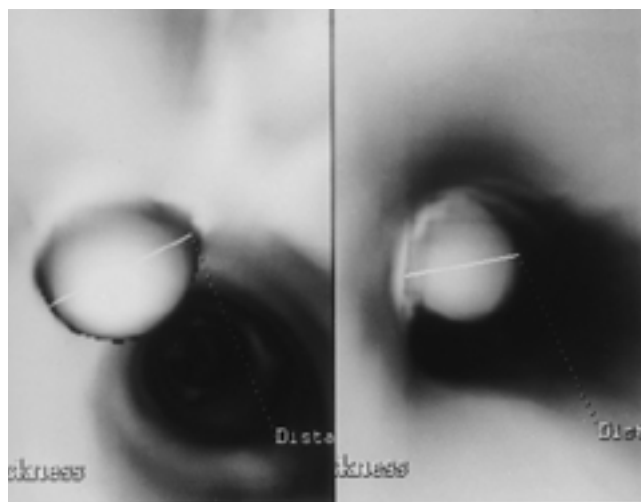


Fig. 6. CT virtual bronchoscopy of simulated endobronchial lesions showing effect of luminal diameter of lesion location. Real sizes of lesions are 8mm. From left to right, luminal diameters of lesion location are 17 mm and 11 mm. As luminal diameter decreases, size of simulated endobronchial lesion decreases.

(3,5,11). phantom 가 (Fig. 2-5), pitch
 (3), 2 pitch가 가
 (1mm, pitch 1) partial volume , 3mm, pitch 1.5, 1mm,
 가 , 3D VB 5mm, pitch 1, 1-1.5mm , -800 HU
 가 3-6mm
 pitch VB , 가 VB
 3mm, pitch 1.5 가 ,
 . pitch (Table
 (stairstep artifact) , 4, Fig. 5,6). 가 ,
 (interpolation) , 1 - , 가
 pitch
 . 7mm , pitch
 partial volume averaging
 , 가 3mm
 (11). Summers (5) 가 VB
 가 pitch가 3mm / 1 100 %-61 %, VB
 3mm / 1.5 96 %-45%, 5mm / 1 100 %-46%
 , 3 VB 2
 78.9%, 77.5%, 73.3% pitch
 가 가 11mm -800 HU,
 가 가 pitch,
 (Table 1, Fig. 2). 가 , 10mm VB
 , 가 가 pitch 가 VB
 , 가 (11). , VB
 CT (over- -500 HU 가 가
 lapping axial image) , partial volume 2
 , 3 , VB
 , 50% , 가
 (10), 80% 가
 (3). 1mm-2mm , (177-199 HU)
 가
 (Table 2, Fig. 3),
 가
 Rodenwaldt (3) VB 가 23mm 11mm 11mm
 3mm, pitch 1.5, 1mm, 85%
 5mm, pitch 1 3mm, pitch 가
 1-2 80% 18.2mm, 가 15.2mm (12),
 , 3mm, 5mm, pitch 1,1.5, 1 mm, VB
 1.5mm, 2mm pitch,
 가 ,
 -800HU 가

VB

pitch, , ,
가 .
3mm, pitch 1.5, 1mm,
5mm, pitch 1, 1-1.5mm , -800HU
가 .

Acknowledgments :

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Virtual Bronchoscopy : An Experimental Study on Parameters Affecting Apparent Sizes of Simulated Endobronchial Lesions¹

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Purpose : To evaluate the scanning parameters affecting the apparent sizes of endoluminal lesions of the tracheobronchial tree, as seen on virtual bronchoscopy (VB), and to determine the optimal CT parameters for demonstrating the real sizes of endobronchial lesions.

Materials and Methods : Spherical beads of 8 mm - 10 mm diameter were randomly placed in the airways of fixed pig lung. CT scans were obtained with collimation and pitch of 3 mm/1, 3 mm/1.5, and 5 mm/1, respectively. Volumetric data were reconstructed with 1 mm-, 1.5 mm-, and 2 mm-collimation for each parameter. VBs were reconstructed with shaded-surface technique and soft tissue algorithm. A 10 mm-sized bead in the trachea and two 8 mm-sized beads in the left main bronchus were selected and their longest diameters were measured on VB at varying thresholds from -800 to -200 HU.

Results : When the measured diameters of beads on VB were recorded as the percentage of real sizes, they were 1) 78.9 %, 77.5 %, and 73.7 % at collimations and pitches of 3 mm/1, 3 mm/1.5, and 5 mm/1, respectively; 2) 77.9 %, 76.9 %, and 75.1 % at 1 mm, 1.5 mm and 2 mm reconstructions, respectively; 3) 86.2 % / 83.4 % / 80.4 % / 77.0 % / 74.8 % / 70.2 % / 64.5 % at isosurface thresholds of -800/-700/-600/-500/-400/-300/-200HU, respectively; 4) 85.6 %, 75.0 %, 69.3 % at 23 mm, 17 mm and 11 mm luminal diameters of lesion location, respectively.

Conclusion : Overall, the diameters of endobronchial lesions are underestimated on VB. As the isosurface threshold values, collimations, pitches and reconstruction intervals decrease in size, the measured diameters approach to real diameter of the beads. Beads in peripheral airways appear smaller than those in proximal airways.

Index words : Bronchi, CT
Bronchoscopy
Computed tomography (CT), three-dimensional

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