

가<sup>1</sup>

1,2 . 3 . 1 . 1 . 1

: 가 가 .

: 가

. 3

(Rapidia , 3D - Med, Seoul, Korea)

가 .

: 1 cm - 200, - 400, - 600 HU 17.3, 2.9,

11.5 (%) - 400 HU 가 가 (r=0.96,  $p < 0.001$ ).

10.9, 5.3, 16.5 % - 400 HU

가 가 (r=1.03,  $p < 0.001$ ).

가 4.6, 16.3, 31.2 % - 200 HU 가 가

(r=1.1,  $p < 0.001$ ).

가 가 가

가 .

: 가 가가 가

. Window setting

.

5 12%

1 5 70% 90 %

(1).

(CT) 가 가 CT 1 cm . (PET)

가 CT 1 cm

가

23%

(2). Mayo clinic 가

1520 CT

50 % ,

가 40% 가 4 mm 50%

4 - 7 mm .

가 .

1

2

3

2001

2001 - 003 - F00161)

2003 3 17

(KRF -

가 가 가 .

가

1 cm





가 : 가

가 2 3D . Yankelevitz (5) segmentation technology  
가 3D data k - means clustering technique, threshold 3D  
volumetric data 가 geometric filter .  
가 2 3  
3  
가 가 2 (5. 6).  
가 가  
가 . 가

**Table 1.** Measured Volumes and Relative Errors of the Synthetic Pulmonary Nodules in Different Threshold Values

Num	Volume				Relative error (%) at each level (HU)		
	Measured at each level (HU)						
	True	- 200 HU	- 400 HU	- 600 HU	- 200 HU	- 400 HU	- 600 HU
1	520	431	503	573	17.1	3.1	10.2
2	560	455	532	606	18.8	5.0	8.3
3	554	454	533	605	18.1	3.8	9.2
4	538	442	517	591	17.8	4.0	9.8
5	550	452	527	600	17.7	4.2	9.1
6	618	509	594	675	17.6	3.8	9.3
7	453	365	431	497	19.5	5.0	9.7
8	570	489	566	644	14.3	0.8	13.0
9	567	467	544	621	17.6	4.0	9.6
10	511	427	499	569	16.4	2.3	11.5
11	536	445	517	589	17.0	3.6	9.9
12	543	454	528	604	16.4	2.7	11.3
13	541	444	521	594	17.8	3.6	9.9
14	594	497	573	650	16.3	3.5	9.4
15	546	470	537	614	14.0	1.6	12.4
16	487	403	472	538	17.2	3.2	10.3
17	563	470	544	616	16.5	3.3	9.4
18	466	383	448	512	17.9	4.0	9.7
19	521	443	512	579	15.0	1.6	11.2
20	542	451	524	594	16.8	3.3	9.7
21	540	465	533	605	13.9	1.2	12.1
22	448	374	439	507	16.6	1.9	13.1
23	309	251	301	352	18.7	2.7	13.8
24	514	421	502	579	18.2	2.4	12.6
25	347	294	348	405	15.1	0.4	16.7
26	277	223	267	312	19.6	3.5	12.4
27	290	236	281	329	18.5	3.1	13.5
28	345	287	340	393	16.8	1.5	14.2
29	277	222	271	318	19.7	2.1	14.9
30	255	204	249	295	20.2	2.5	15.7
31	222	178	214	252	19.9	3.4	13.8
Mean	471.1	390.5	457.0	523.2	17.3	2.9	11.5
SD	115.9	99.2	111.5	123.1	1.7	1.1	2.2

**Table 2.** Relationship of True and Measured Volumes of the Synthetic Nodules in Various Threshold Values

HU	Linear regression		Bias	95% limits of agreements	
	Slope ( $p < 0.001$ )	Intercept		Upper	Lower
- 200	0.85	- 11.44	- 80.54	- 44.55	- 116.54
- 400	0.96	4.51	- 14.03	0.17	- 28.23
- 600	1.06	23.84	52.15	71.12	33.18

가 가 . 가 1) (soft tissue setting). window width (WW) 400 HU, window level (WL) 20 HU; 2) (lung setting). WW 850 HU, WL -750 HU; 3) (broad lung setting), WW 1350 HU, WL -550 HU

CT CT가 window

window level . 가

window level . Harris

(7) 20 HU .

window level

**Table 3.** Measured Volumes and Relative Errors of the Calcified Pulmonary Nodules in Different Threshold Values

Number	Volume				Relative error (%) at each level (HU)		
	Measured at each level (HU)						
	True	- 200 HU	- 400 HU	- 600 HU	- 200 HU	- 400 HU	- 600 HU
1	2783	2707	2936	3157	2.7	5.5	13.5
2	2352	2200	2414	2613	6.5	2.6	11.1
3	3254	2687	3285	3646	17.4	1.0	12.1
4	2822	2917	3093	3301	3.4	9.6	17.0
5	1839	1521	1810	2016	17.3	1.6	9.6
6	1279	1229	1348	1492	3.9	5.4	16.7
7	1254	1026	1239	1396	18.1	1.2	11.3
8	1375	1378	1507	1659	0.2	9.6	20.7
9	1411	1328	1538	1781	5.9	9.0	26.2
10	1067	805	1008	1167	24.5	5.6	9.4
11	1390	1421	1534	1676	2.2	10.4	20.6
12	1300	1197	1352	1530	7.9	4.0	17.7
13	1355	1087	1329	1490	19.8	1.9	10.0
14	4533	4365	4712	5016	3.7	3.9	10.7
15	8055	7858	8388	8840	2.4	4.1	9.7
16	11295	10902	11575	12133	3.5	2.5	7.4
17	1220	1170	1286	1410	4.1	5.4	15.5
18	962	867	982	1097	9.9	2.1	14.0
19	868	666	827	952	23.2	4.7	9.7
20	832	779	884	997	6.4	6.3	19.8
21	814	737	844	955	9.5	3.7	17.3
22	729	533	705	834	26.8	3.3	14.4
23	849	870	981	1254	2.5	15.6	47.7
24	937	866	993	1130	7.6	6.0	20.6
25	792	612	785	912	22.8	0.9	15.1
26	972	991	1121	1329	1.9	15.3	36.7
27	512	435	511	589	15.1	0.3	15.0
28	413	288	386	461	30.2	6.6	11.6
29	965	915	1026	1142	5.2	6.3	18.4
30	700	637	735	837	9.0	5.0	19.5
31	568	427	548	645	24.9	3.5	13.6
Mean	1919	1788	1990	2176	10.9	5.3	16.5
SD	2296	2242	2368	2468	9	4	8

**Table 4.** The Relationship of True and Measured Volumes of the Synthetic Calcified Nodules in Various Threshold Values

HU	Linear regression		Bias	95% limits of agreements	
	Slope ( $p < 0.001$ )	Intercept		Upper	Lower
- 200	0.97	84.18	- 131.51	132.51	- 395.52
- 400	1.03	10.67	70.47	265.03	- 124.09
- 600	1.07	113.99	256.77	632.81	119.261

**Table 5.** Measured Volumes and Relative Errors of the Synthetic Pulmonary Nodules Adjacent to Vessels in Different Threshold Values

Number	Volume				Relative error (%) at each level (HU)		
	Measured at each level (HU)						
	True	- 200 HU	- 400 HU	- 600 HU	- 200 HU	- 400 HU	- 600 HU
1	938	885	1064	1200	5.7	13.4	30.0
2	902	867	1058	1913	3.8	17.4	33.1
3	1564	1488	1713	3898	4.8	9.6	22.3
4	2944	3208	3597	1506	9.0	22.2	32.4
5	1150	1122	1324	1305	2.4	15.2	30.9
6	994	969	1149	1462	2.5	15.6	31.3
7	1122	1125	1305	3354	0.2	16.2	30.2
8	2502	2708	3060	629	8.2	22.3	34.0
9	497	407	523	1368	18.1	5.2	26.6
10	1067	1063	1239	6503	0.4	16.1	28.2
11	4747	5357	5967	1815	12.8	25.7	37.0
12	1297	1360	1596	920	4.8	23.0	39.9
13	727	670	794	1250	7.8	9.2	26.6
14	957	937	1108	2591	2.0	15.8	30.6
15	1978	2082	2363	1449	5.3	19.4	31.0
16	1104	1124	1312	1631	1.8	18.9	31.2
17	1242	1184	1426	1264	4.6	14.8	31.4
18	948	948	1126	1657	0.1	18.8	33.4
19	1260	1269	1467	1718	0.7	16.4	31.4
20	1279	1337	1543	997	4.6	20.7	34.4
Mean	1461	1506	1737	1922	4.6	16.3	31.2
SD	968	1123	1233	1334	5	5	4

**Table 6.** The Relationship of True and Measured Volumes of the Synthetic Pulmonary Nodules Adjacent to Vessels in Various Threshold Values

HU	Linear regression		Bias	95% limits of agreements	
	Slope ( $p < 0.001$ )	Intercept		Upper	Lower
- 200	1.16	- 188.92	44.63	359.02	- 269.76
- 400	1.27	- 123.97	275.79	802.48	- 250.89
- 600	1.37	- 69.31	471.68	1181.71	- 238.337

가

가

2.9 %

가

0 - 100 HU

- 200, - 400, - 600 HU

17.3%, 2.9%,

11.5% .

- 400 HU

가

가

가

가

가

5%

가

- 200, -

400, - 600 HU

4.6%, 16.3%, 31.2%

가

- 200, - 400, -

가

600 HU

10.9%, 5.3%, 16.5%

- 400 HU

가

segmentation

- 107

## Evaluation of Computer Aided Volumetry for Simulated Small Pulmonary Nodules on Computed Tomography<sup>1</sup>

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**Purpose:** To determine the accuracy of automated computer aided volumetry for simulated small pulmonary nodules at computed tomography using various types of phantoms

**Materials and Methods:** Three sets of synthetic nodules (small, calcified and those adjacent to vessels) were studied. The volume of the nodules in each set was already known, and using multi-slice CT, volumetric data for each nodule was acquired from the three-dimensional reconstructed image. The volume was calculated by applying three different threshold values using Rapidia software (3D-Med, Seoul, Korea).

**Results:** Relative errors in the measured volume of synthetic pulmonary nodules were 17.3, 2.9, and 11.5% at - 200, - 400, and - 600 HU, respectively, and there was good correlation between true volume and measured volume at - 400 HU ( $r=0.96$ ,  $p<0.001$ ). For calcified nodules, relative errors in measured volume were 10.9, 5.3, and 16.5% at - 200, - 400, and - 600 HU, respectively, and there was good correlation between true volume and measured volume at - 400 HU ( $r=1.03$ ,  $p<0.001$ ). In cases involving synthetic nodules adjacent to vessels, relative errors were 4.6, 16.3, and 31.2 % at - 200, - 400, and - 600 HU, respectively. There was good correlation between true volume and measured volume at - 200 HU ( $r=1.1$ ,  $p<0.001$ ).

**Conclusion:** Using computer-aided volumetry, the measured volumes of synthetic nodules correlated closely with their true volume. Measured volumes were the same at each threshold level, regardless of window setting.

**Index words :** Computed tomography (CT), computer programs  
Lung, nodule  
Lung neoplasms, CT

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