

CT

1

2

CT  
 가  
 가  
 CT  
 13 14 13 4  
 CT  
 1 mm<sup>2</sup> Hounsfield  
 unit (HU) whirlpool  
 가, ,  
 :  
 69% 94% HU  
 9 (69%) 가 100% 가 94% 가  
 (38%), 4 (22%), 10 (56%), 가 5  
 5 (38%), 3 (17%)가  
 4 (31%) 5 (28%)가  
 : CT HU

20%가 (11 - 15). 가  
 가 가 가  
 가 (1, 2). (6, 7, 16).  
 가 가 (7, 16)  
 37% (3, 4).  
 CT  
 (1, 5 - 10).  
 CT (16, 17).  
 가 CT  
 가

Hounsfield Unit (HU)

HU

가

<sup>1</sup>  
<sup>2</sup>

가 ( , ) , 69% HU 가 25HU (Table 1, 3). 94% 가 . CT (n=13)가 가 , (n=9), 가(n=5), CT 1996 5 2001 9 가 31 CT 13 14 (n=3) , (n=1)가 2 88 ( 53 ) , 20 11 . CT GE HiSpeed Advantage (GE medical systems, Milwaukee, WI, U.S.A.) 120 ml (Iohexol 300 mg/ml, Omnipaque™, NYCOMED, Cork, Ireland) (MCTPlus, Medrad, Pittsburgh, PA, U.S.A.) 3 ml/sec 5 - 7 mm 1.4:1 pitch, 7 mm CT 30 70 - 80 CT (4.5 ) 1 mm<sup>2</sup> (region of interest, ROI) HU HU 3 (subtraction) (whirlpool) , 가, 3 mm (17). HU Student t - test exact test CT 가 Fisher 56.5 ± 22.6 , 12.4 ± 11.4 가 (p<0.001) (Table 1, 2) (Fig. 1).

**Table 1.** Distribution of HU of Bowel Wall between Strangulated and Non-strangulated Small Bowel Obstruction

	Number of patients	HU of Well Enhanced Bowel (A)	HU of Poorly Enhanced Bowel (B)	A - B
Patients of strangulation	1*	93.3	10.0	83.3
	2*	88.7	46.7	42
	3	83.0	47.5	35.5
	4*	120.0	58.0	62
	5*	104.7	37.7	67
	6	82.0	53.7	28.3
	7*	89.3	48.0	41.3
	8	93.0	48.7	44.3
	9*	98.7	10.4	88.3
	10*	118.3	24.8	93.5
	11*	121.3	49.4	71.9
	12	95.3	47.3	48
	13*	105.0	76.0	29
Patients of non-strangulation	1	100.3	108.0	- 7.7
	2	106.0	98.3	7.7
	3	102.0	100.7	1.3
	4	76.3	81.3	- 5.0
	5	85.3	64.3	21.0
	6	73.0	77.3	- 4.3
	7	87.7	90.7	- 3.0
	8	86.0	84.7	1.3
	9	100.7	94.0	6.7
	10	117.3	106.3	11.0
	11	113.0	97.3	15.7
	12	94.0	80.7	13.3
	13	73.3	93.0	- 19.7
	14	117.0	100.3	16.7
	15	88.3	103.3	- 15.0
16	84.7	83.0	1.7	
17*	91.3	42.7	48.7	
18	81.7	58.3	23.3	

No\*: Patients who were diagnosed for strangulation with only visual assessment by radiologist.

**Table 2.** Comparison of Difference of HU of Bowel Wall between Strangulated and Non-strangulated Small Bowel Obstruction

	Strangulation	Non-strangulation
Mean (A-B)*	56.5	12.4
S.D.†	22.6	11.4

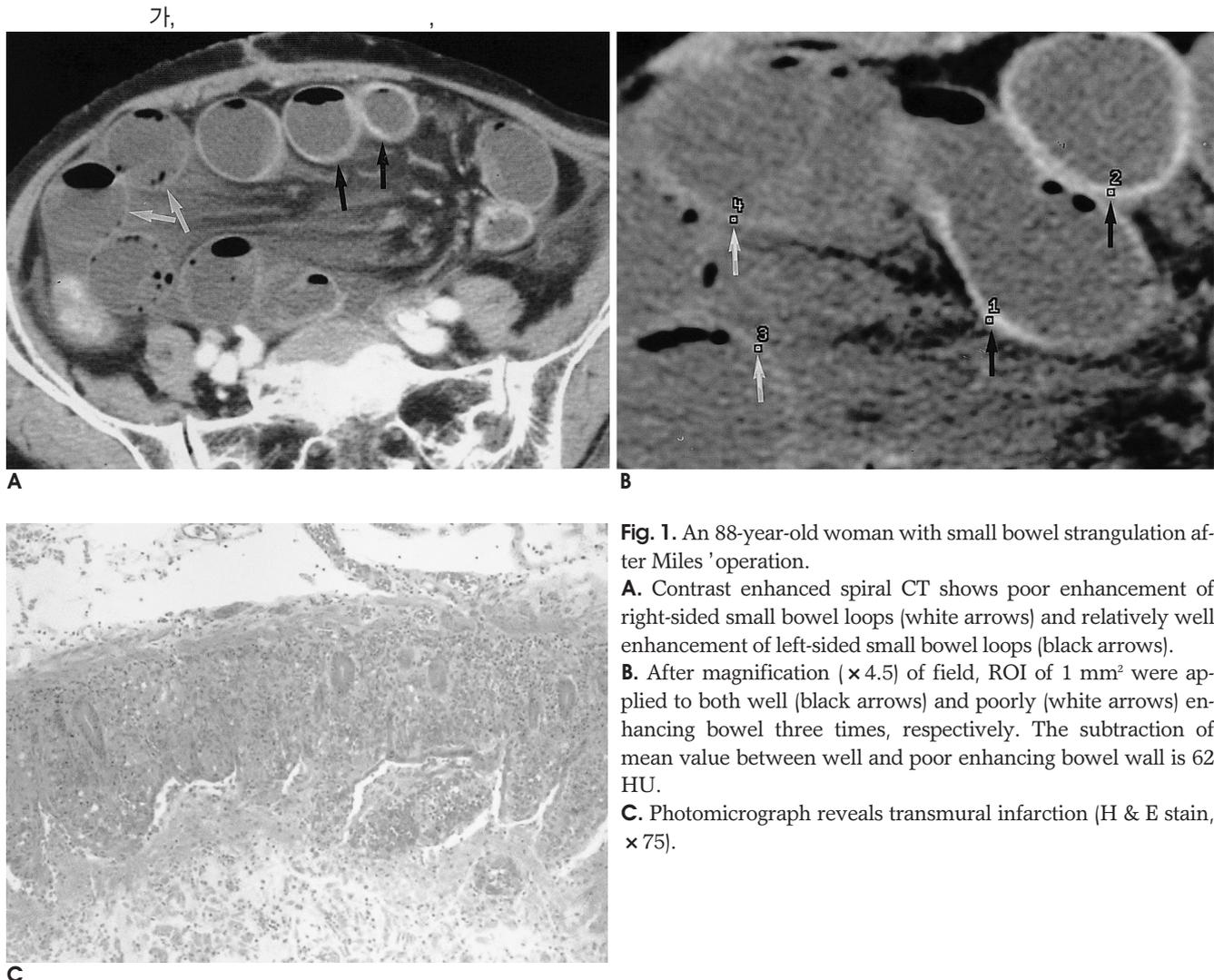
Student t-test: p < 0.001  
\*A-B: HU of well enhanced bowel wall - HU of poorly enhanced bowel wall in same patient, †S.D.: Standard Deviation

(n=5), (n=4) 가 (Table 3).  
 (n=1), (n=10), 가 (n=4), (n=3),  
 (n=5)  
 Fisher exact test (6, 7, 16, 17).  
 HU ( 가 25 HU )  
 p-value (p<0.001),

**Table 3.** CT Signs of Strangulated and Non-strangulated Small Bowel Obstruction

CT signs	Strangulation (n = 13)		Non-strangulation (n = 18)		p-value
	n	%	n	%	
Reduced Bowel Wall Enhancement					
Measure of HU*	13	100	1	5	<0.001
Visual Assessment	9	69	1	5	<0.001
Ascites	9	69	10	55	0.48
Thickening of Bowel Wall	5	38	4	22	0.43
Displacement of SMA <sup>†</sup>	5	38	3	16	0.23
Venous Engorgement	4	30	5	27	1.00

\* Hounsfield Unit, <sup>†</sup>Superior Mesenteric Artery



가, ( ) 가  
 HU 가 12.4±  
 11.4 23.8 HU 가  
 22.6 HU 가 25 - 30 HU 가  
 HU  
 가 48.7 가 ,  
 (Fig. 1).



**Fig. 2.** Contrast enhanced CT scan of an 81-year-old woman shows relatively poor enhancement of dilated small bowel loop (black arrows) than collapsed small bowel loops in right abdomen (white arrows). There are also whirlpool appearance, mesenteric venous engorgement (long black arrows), and ascites (long white arrows). These are suggestive of strangulation of small bowel obstruction. But no strangulation was found at operation and pathologist results.

CT  
 Ha (8)  
 (98%)가  
 ( )  
 (7)  
 87.5%, 90%) ( 75%, 75.8%)  
 CT  
 (69%)  
 (44%)가  
 3 mm  
 2 mm  
 (17).  
 가,  
 (double  
 halo)  
 Macari (17)  
 (16). CT 38%  
 83%  
 (internal hernia)  
 (95%)  
 (72%) (17).  
 CT

가 HU  
 가 25 HU

1. Gore RM, Levine MS. *Textbook of gastrointestinal radiology*. 2nd ed. Philadelphia: Saunders, 2000; 815-816
2. Federle MP, Chun G, Jeffrey RB, Rayor R. Computed tomographic findings in bowel infarction. *AJR Am J Roentgenol* 1984;142:91-95
3. Sarr MG, Bulkley GB, Zuidema GD. Preoperative recognition of intestinal strangulation obstruction: prospective evaluation of diagnostic capability. *Am J Surg* 1983;145:176-182
4. Mucha P Jr. Small intestinal obstruction. *Surg Clin North Am* 1987; 67:597-620
5. Caoili EM, Paulson EK. CT of small-bowel obstruction: another perspective using multiplanar reformations. *AJR Am J Roentgenol* 2000;174:993-998
6. Furukawa A, Yamasaki M, Furuichi K, Yokoyama K, Nagata T, Takahashi M, et al. Helical CT in the diagnosis of small bowel obstruction. *Radiographics* 2001;21:341-355

7. Zalcman M, Sy M, Donckier V, Closset J, Gansbeke DV. Helical CT signs in the diagnosis of intestinal ischemia in small-bowel obstruction. *AJR Am J Roentgenol* 2000;175:1601-1607
8. Scaglione M, Romano S, Pinto F, Flagiello F, Farina R, Acampora C, et al. Helical CT diagnosis of small bowel obstruction in the acute clinical setting. *Eur J Radiol* 2004;50:15-22
9. Ha HK, Rha SE, Kim JH. CT diagnosis of strangulation in patients with small bowel obstruction: current status and future direction. *Emerg Radiol* 2002;7:47-55
10. Scaglione M, Grassi R, Pinto A, Giovine S, Gagliardi N, Stavoletto C, et al. Positive predictive value and negative predictive value of spiral CT in the diagnosis of closed loop obstruction complicated by intestinal ischemia. *Radiol Med* 2003;105:69-77
11. Balthazar EJ, Liebeskind ME, Macari M. Intestinal ischemia in patients in whom small bowel obstruction is suspected: evaluation of accuracy, limitations, and clinical implications of CT in diagnosis. *Radiology* 1997;205:519-522
12. Balthazar EJ, Birnbaum BA, Megibow AJ, Gordon RB, Whelan CA, Hulnick DH. Closed-loop and strangulating intestinal obstruction: CT signs. *Radiology* 1992;185:769-775
13. Frager D, Baer JW, Medwid SW, Rothpearl A, Bossart P. Detection of intestinal ischemia in patients with acute small-bowel obstruction due to adhesions or hernia: efficacy of CT. *AJR Am J Roentgenol* 1996;166:67-71
14. Makita O, Ikushima I, Matsumoto N, Arikawa K, Yamashita Y, Takahashi M. CT differentiation between necrotic and nonnecrotic small bowel in closed loop and strangulating obstruction. *Abdom Imaging* 1999;24:120-124
15. Burkill G, Bell J, Healy J. Small bowel obstruction: the role of computed tomography in its diagnosis and management with reference to other imaging modalities. *Eur Radiol* 2001;11:1405-1422
16. Ha HK, Kim JS, Lee MS, Lee HJ, Jeong YK, Kim PN, et al. Differentiation of simple and strangulated small-bowel obstructions: usefulness of known CT criteria. *Radiology* 1997;204:507-512
17. Macari M, Balthazar EJ. CT of bowel wall thickening: significance and pitfalls of interpretation. *AJR Am J Roentgenol* 2001;176:1105-1116

## Usefulness of Helical CT in the Diagnosis of Strangulation in Small Bowel Obstruction<sup>1</sup>

Young-Hye Kang, M.D., Won-Hong Kim, M.D., Yong-Sun Jeon, M.D., Dong-Jae Shim, M.D.,  
Soon-Gu Cho, M.D., Chang-Keun Lee, M.D., Sun-Keun Choi, M.D.<sup>2</sup>

<sup>1</sup>Department of Radiology, Inha Univ. College of Medicine

<sup>2</sup>Department of Surgery, Inha Univ. College of Medicine

**Purpose:** We wished to evaluate the usefulness of helical CT for the diagnosis of strangulation of the dilated small bowels.

**Materials and Methods:** The CT scans of 31 patients with small bowel obstruction from various causes were reviewed retrospectively. Thirteen of these patients were confirmed as small bowel strangulation by surgery and pathology. Fourteen patients underwent surgery, but they had no strangulation. Three patients were reduced by using a nasogastric tube and one infant with intussusception was reduced by air reduction. The following CT findings of strangulation were evaluated: reduced bowel wall enhancement by visual assessment and measuring the HU, ascites, thickening of bowel wall, abnormal mesenteric vessel location and whirlpool appearance, and mesenteric venous engorgement. For the precise evaluation of reduced bowel wall enhancement, the HUs were measured by 1 mm<sup>2</sup> of ROI, and the differences of HUs between the well enhanced bowel and poorly enhanced bowel were compared.

**Results:** For the diagnosis of strangulation, measurement of HU of the bowel wall could improve the sensitivity from 69% to 100%. The specificity of both methods, by visual assessment and measurement of HU, was 94%. Ascites had a sensitivity of 69% and specificity of 44%. Thickening of bowel wall had a sensitivity of 38% and specificity of 78%. Abnormal mesenteric vessel location and whirlpool appearance had a sensitivity of 38% and specificity of 83%. Mesenteric venous engorgement had a sensitivity of 31% and specificity of 72%.

**Conclusion:** Measurement of HU of the bowel wall after contrast enhancement can be a useful method in the differential diagnosis between the strangulated and non-strangulated bowels in patients with small bowel obstruction.

**Index words :** Intestines, CT  
Intestines, infarction  
Intestines, ischemia  
Intestines, stenosis or obstruction

Address reprint requests to : Won-Hong Kim, M.D., Department of Radiology, Inha University Hospital,  
7-206 3rd St., Shinheung-dong, Choong-gu, Incheon 400-103, Korea.  
Tel. 82-32-890-2769 Fax. 82-32-890-2743 E-mail: kwh2701@inha.ac.kr