Medical Science Journal for Advance Research

Vol. 7, No. 2, June 2026
e-ISSN: 2774-4892

Changes in the Number of Interstitial Cells of Cajal in the Gastrointestinal Tract in Mechanical Ileus

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ABSTRACT

Background: *The Interstitial cells of Cajal(ICC) were named by the Nobel Prize winner, the Spanish neuroanatomist Santiago Ramony Cajal (1852-1934). Interstitial cells of Cajal are mesenchymal cells in the stroma of the gut smooth muscle that are present between the nerve and smooth muscle and function as pacemaker cells because of the active generation of depolarized electrical slow waves of the smooth muscle system. In the human digestive tract, ICC are found in or around the myometrial lining of the esophagus, stomach, small intestine and large intestine. Mechanical ileus causes compensatory hyperperistalsis to resolve the initial obstruction, and ultimately results in decompensated peristalsis.* ***The aim:*** *We aimed to investigate the changes in the number of ICC cells in the clinical picture of mechanical ileus.* ***Methods:*** *The study population included 90 bowel resections accepted by the pathology department for mechanical ileus and 24 bowel resections from autopsy without digestive tract disease. Twenty-four autopsies (20-30 years) without digestive tract disease (from the body), small intestine (20 cm above ileum) and large intestine (from the ileocecal region) were obtained, and H-E and silver nitrate staining (Silver staining) specimens were prepared according to the conventional tissue sampling technique and the number of normal cord stromal cells under ×400 light microscope was calculated. H-E stained samples of bowel resection specimens from patients with mechanical ileus and silver nitrate stained samples were calculated as the number of Interstitial cells of Cajal (under ×400 light microscope, distributed between the cricoid and the longitudinal muscles) according to the site of development of the gastrointestinal tract and the number of days of the first defecation. At this time, pathological examination was performed on the lesion center and surrounding histopathology microscopically, and the interpretation of the changes in the number of Interstitial cells of Cajal was performed around the lesion because the anterior intestinal layer was completely necrotic in the lesion center and no normal structure was found.* ***Results and Conclusions:*** *The changes in the number of normal ICC cells in the gastrointestinal tract and ICC by GI site in mechanical ileus are as follows : 1) Normal ICC in the gastrointestinal tract was significantly enriched in the gastric corpus (22.0/ under ×400 light microscope) and ileum (26.2/ under ×400 light microscope). 2) Mechanical ileus was associated with significantly higher numbers of Interstitial cells of Cajal when it occurred in the small intestine and ileocecal region than in the large intestine, and the longer the first defecation period (coarctation ileus) the significantly lower number of Interstitial cells of Cajal.*

Keywords: Interstitial cells of Cajal , Gastrointestinal Tract, Mechanical ileus.

Article Information

Received: April 25, 2026; Revised: May 22, 2026; Online: June 2026

https://doi.org/10.46966/msjar.v7i2.401

INTRODUCTION

Interstitial cells of Cajal (ICC) were named by the Nobel Prize winner, the Spanish neuroanatomist Santiago Ramony Cajal (1852-1934). Interstitial cells of Cajal are mesenchymal cells in the stroma of the gut smooth muscle that are present between the nerve and smooth muscle and function as pacemaker cells because of the active generation of depolarized electrical slow waves of the smooth muscle system[3,5,11]. ICC are smaller in size, similar to or smaller than adjacent smooth muscle cells, with spindle-shaped or star-shaped and abundant cellular processes dividing[1,7,10,16].

Interstitial cells of Cajal contain large oval nucleus surrounded by weakly stained cytoplasm.

In the human digestive tract, ICC are found in or around the myometrial lining of the esophagus, stomach, small intestine and large intestine[3,10,17,19].

The cycle of activity of Interstitial cells of Cajal as pacemaker cells varies in different regions of the gastrointestinal tract, 3 times in the stomach, 12 times in the duodenum, 10 times in the ileum, and 3 times in the colon. In abdominal surgery, mechanical ileus is one of the most frequent diseases caused by both strangulation and obstructive causes and surgical intervention is required. Mechanical ileus causes compensatory hyperperistalsis to resolve the initial obstruction and ultimately results in decompensated peristalsis. Currently, we are looking at the dynamics of changes in ICC in gastrointestinal motility disorders and trying to tailor the changes in response to increased bowel motility and inhibition[2,12,15]. We aimed to investigate the changes in the number of ICC cells in the clinical picture of mechanical ileus.

SUBJECTS AND METHODS

The study population included 90 bowel resections for past 5 years, accepted by the pathology department for mechanical ileus at the Pyongyang University Hospital of Medical Sciences and 24 bowel resections from autopsy without digestive tract disease. The sex and age composition of patients with mechanical ileus showed that 40 (36.8%) in men, 60 (27.3%) in women, 40 (28.9%) in men and women and a mean age of 42.3 years, with male to female ratio of 1.7:1. Twenty-four autopsies (20-30 years) without digestive tract disease (from the body), small intestine (20 cm above ileum) and large intestine (from the ileocecal region) were obtained and H-E and silver nitrate staining (Silver staining) specimens were prepared according to the conventional tissue sampling technique and the number of normal cord stromal cells under ×400 light microscope view was calculated.

H-E stained samples of bowel resection specimens from patients with mechanical ileus and silver nitrate stained samples were calculated as the number of Interstitial cells of Cajal (under ×400 light microscope view, distributed between the cricoid and the longitudinal muscles) according to the site of development of the gastrointestinal tract and the number of days of the first defecation.

At this time, pathological examination was performed on the lesion center and surrounding histopathology microscopically, and the interpretation of the changes in the number of Interstitial cells of Cajal was performed around the lesion because the anterior intestinal layer was completely necrotic in the lesion center and no normal structure was found.

The significance test was performed by Student's t-test for the mean of the study results and by Chi-square test for the percentage of the study results.

The clinical pathological diagnosis of mechanical ileus were performed according to clinicopathological diagnosis and treatment guidelines published by the Ministry of Public Health, DPRK.

RESULTS

Table 1.Number of Interstitial cells of Cajal for normal gastrointestinal tract.

Classification	Cases	Cells per normal gastrointestinal tract ($\overline{X}$ ±SE)		
		Gastric corpus	Ileum	Transverse colon
Number of cells	24	22.0±2.8	26.2±3.1	6.4±0.8
P		<0.05	<0.05	—

As shown in Table 1, the number of ICC per normal gastrointestinal tract was significantly higher in the corpus and ileum.

Table 2. Pathological diagnosis of mechanical ileus

Classification		Cases	Inflammation		Necrosis	Tumor
			Necrotic	Tuberculotic		
Strangulated ileus	Adhesive ileus	32	9* (28.1)	1 (3.1)	17* (53.2)	5 (15.6)
	invagination	14	5* (35.7)	1 (7.1)	5* (35.7)	3 (21.4)
obstructive ileus		44	14* (31.8)	2 (4.6)	21* (47.7)	7 (15.9)

(); % *; P<0.05 (compared with pathological diagnosis)

As shown in Table 2, all mechanical ileus cases had significantly more necrotic inflammation and necrosis on pathological diagnosis, individually.

Table 3. Changes of the number of ICC in the site of gastrointestinal in mechanical ileus

Classification		Cases	Interstitial cells of Cajal number ($\overline{X}$ ±SE, n)					
			Small intestine		Iloececum	colon		
			Jejunum	Ileum		Ascending	Transverse	Sigmoid
Strangulated ileus	Adhesive ileus	32	8.8*Δ ±0.8 (4)	6.4*Δ ±0.6 (6)	3.4*Δ ±0.4 (19)	-	2.8*Δ ±0.3 (1)	1.6 ±0.2 (2)
	invagination	14	10.1*Δ ±1.1 (1)	-	5.6*Δ ±0.7 (11)	2.8* ±0.3 (2)	-	-
obstructive ileus		44	22.8Δ ±2.0 (7)	22.6Δ ±1.8 (7)	19.4Δ ±1.6 (23)	13.8Δ ±1.2 (5)	5.6 ±0.4 (2)	-

(); cases, *; P<0.05 (compared with obstructive ileus), Δ; P<0.05 (comparison with gastrointestinal tract sites).

As shown in Table 3, compared with obstructive ileus, there were significantly fewer ICC in all developing regions of the gastrointestinal tract in the case of Strangulated ileus, and significantly more ICC in all mechanical ileus, individually, in the upper developing regions compared with the lower developing regions.

Table 4. Changes of the number of ICC per day of first defecation in mechanical ileus ($\overline{X}$ ±SE)

Classification		**Cases**	**first defecation period(day)**	**number of Interstitial cells of Cajal(n)**
Strangulated ileus	Adhesive ileus	32	5.8±0.6*	4.6±0.5*
	invagination	14	5.4±0.6*	6.2±0.7*
obstructive ileus		44	3.6±0.4	16.8±1.4

*; P<0.05 (compared with obstructive ileus)

As shown in Table 4, the first defecation period was significantly longer in the case of Strangulated ileus ileus compared with obstructive ileus, individually, and the number of ICC cells was significantly lower.

DISCUSSION

Ileus(Intestinal obstraction) is syndrome that causes difficulty in the passage of intestinal contents by variety of causes and is classified as functional or mechanical ileus by cause and pathogenesis. Functional ileus are divided into spasticity and paralytic ileus and mechanical ileus are divided into obstructive and binocular ileus. In abdominal surgery clinical practice, mechanical ileus is frequent disease caused by adherent biting and overlapping causes requiring surgical intervention. Interstitial cells of Cajal were named by the Nobel Prize winner, the Spanish neuroanatomist Santiago Ramon y Cajal (1852-1934). ICC was first found in the gastrointestinal tract and acts as pacemaker to generate electrical rhythms that cause smooth muscle contraction[4,6,9].

We compared the number of ICC in the normal gastrointestinal tract and the number of ICC in different gastrointestinal sites during mechanical ileus in 114 cases including 90 resected bowel specimens and 24 resected bowel specimens without digestive tract disease in the last 6 years. The number of cases of mechanical ileus classified and the mean age of the study population were significantly higher in male compared to female in 37.5% and male in female in synaptic compared with 62.5% in male and 35.7% in female in overlapping and 63.6% in male compared to 36.4% in female in obstructive ($P < 0.05$). This indicates that the age at onset of ileus is clinically greater in the 40 years of age and the incidence of ileus is higher in men compared to women.

Our observation of the number of cells per gastrointestinal tract of ICC showed that the number of cells present was significantly higher in the gastric corpus and ileum compared to the colon, with 22.0 cells present in the gastric corpus, 26.2 cells in the ileum and 6.4 cells in the transverse colon (P<0.05 Table 1). This is in good agreement with the literature data that the cycle of activity of Interstitial cells of Cajal as pacemaker cells varies in different regions of the gastrointestinal tract, three times in the stomach, 12 times in the duodenum, 10 times in the ileum and three times in the colon. According to the literature, the pathogenesis of mechanical ileus is as follows. Obstructive ileus is caused by tumor compression, obstruction, inflammation, scarring, and intestinal causes, foreign body, ascarid worm, adhesions from extramural causes and tumor-induced compression. Strangulated ileus is form of ileus accompanied by blood circulation disorders and neuropathy which is characterized by the presence of volvulus,

adherent bite, herniation, overlap and nodulation, and is a severe course. Adhesive ileus is usually a non-invasive but in some cases it is a frequent occurring cause of approximately 80% of the commitment. The causes are the same as those of adhesive ileus which include coarse surgery, peritonitis, intraperitoneal bleeding and intraperitoneal tuberculosis. Intussusception is common form of intussusception that occurs when the bowel enters the adjacent bowel with the mesenteric membrane and occurs predominantly in children under 2 years of age.

There are many functional reasons in children which are easily caused by the immaturity of intestinal and mesenteric development, the difference in caliber of the large intestine and small intestine and the difference in motility of the small intestine and the limited mobility of the enteric peristalsis. In adults, there are many organic causes such as tumors (cancer, polyps, etc.) and foreign bodies. In our comparative clinical diagnostic pathology of mechanical ileus, necrotizing inflammation and necrosis were significantly more frequent in 28.1% and 53.2% adherent, 35.7% in overlapping, 31.8% and 47.7% in obstructive, individually (P<0.05, Table 2).

On the other hand, mechanical ileus was also associated with tuberculosis and tumors on pathological diagnosis, with 3.1% and 15.6% of adhesive ileus, 7.1% and 21.4% in overlapping adults, individually and 4.6% and 15.9% in obstructive adults, individually (Table 2). Thus, both of the mechanical ileus cases had predominant proportion of necrotic and necrotic inflammation on pathological diagnosis with small number of cases of tuberculosis and neoplastic disease. Interstitial cells of Cajal act as electrical pacemakers, generating autonomic electrical slow waves in the gastrointestinal tract. Electroslow waves are transmitted from ICC to smooth muscle cells resulting in depolarization which results in influx and contraction of calcium ions.

As a result, slow waves cause gastrointestinal contractions which are the basis of peristalsis and segmental motion[8,13,18]. We compared the number of Interstitial cells of Cajal underlying the development of peristalsis in mechanical ileus by site-specific gastrointestinal development, 8.8 for adhesive cements in jejunum, 10.1 for intussusception, and 22.8 for obstructive ileus which were significantly less for the development of Strangulated ileus than for obstructive ileus(P<0.05). 6.4 adhesive ileus and 22.6 in obstructive ileus were significantly less in adhesive ileus compared with obstructive ileus (P<0.05), 3.4 adhesive ileus, 5.6 in invagination and 19.4 in obstructive ileus, significantly less in the presence of obstructive ileus (P<0.05, Table 3). Also, 2.8 cases in the ascending colon and 13.8 cases in the obstructive colon were significantly less in the obstructive ileus compared with obstructive ileus (P<0.05), 2.8 cases in the transverse colon and 5.6 cases in the obstructive colon which were significantly less in the adhesive compared to obstructive ileus (P<0.05 Table 3).

On the other hand, according to the site of occurrence of gastrointestinal tract, there were significantly greater numbers of jejunum (8.8), ileum (6.4), ileocele (3.4), and transverse colon (2.8), jejunum (10.1) and ileocele (5.6) in the presence of adherent strangulation, and jejunum (5.6). The results of the above study indicate that the site of induction of mechanical ileus is the jejunum, ileum and ileocecal region and that there is a large number of changes in the number of ICC in these areas, among which there is a large reduction in ICC in Strangulated ileus ileus and relatively small reduction in ICC compared to Strangulated ileus ileus in obstructive ileus. We compared the number of Interstitial cells of Cajal for mechanical ileus clinically, the first defecation period was 5.8 days for adhesive ileus, 5.4 days for intussusception, and 3.6 days for

obstructive ileus which was significantly longer in the case of Strangulated ileus compared with obstructive ileus (P<0.05).

The number of ICC was significantly less in Strangulated ileus compared with Occlusive ileus with 4.6 in adhesive coarctation, 6.2 in invagination and 16.8 in Occlusive ileus (P < 0.05, Table 4). This is study that demonstrates that Interstitial cells of Cajal function as direct carriers of the development of intestinal motility with clinical and histopathological changes in the number of days of first defecation and the number of ICC being inversely correlated suggesting that ICC are more prone to dysmotility in Strangulated ileus than obstructive ileus.

CONCLUSION

The changes in the number of normal ICC in the gastrointestinal tract and ICC by GI site in mechanical ileus are as follows :

1) Normal ICC in the gastrointestinal tract was significantly enriched in the gastric corpus (22.0) and ileum (26.2).

2) Mechanical ileus was associated with significantly higher numbers of Interstitial cells of Cajal when it occurred in the small intestine and ileocecal region than in the large intestine and the longer the first defecation period(strangulated ileus) the significantly lower number of Interstitial cells of Cajal.

REFERENCES

1. Streutker C J, Huizinga J D, Driman D K & Riddell R H. Interstitial cells of Cajal in health and disease. Part I: Normal ICC structure and function with associated motility disorders. (2007) Histopathology 50, 176–189
2. Ahad Eshraghian, Hamed Eshraghian. Interstitial cells of Cajal: A novel hypothesis for the pathophysiology of irritable bowel syndrome. can J Gastroenterol. 2011;25(5):277-279
3. Goran Radenković, Ivan Nikolić, Vera Todorović. Interstitial Cells Of Cajal– Pacemakers Of The Intestinal Musculature. Medicine and Biology Vol.12, No 1, 2005, pp. 1 – 5
4. Byung Joo Kim, In Youb Chang, Seok Choi, Jae Yeoul Jun, Ju-Hong Jeon, Wen-Xie Xu, Young Kyu Kwon, Dejian Ren and Insuk So. Involvement of Na^+-leak Channel in Substance P-induced Depolarization of Pacemaking Activity in Interstitial Cells of Cajal. Cell Physiol Biochem 2012;29:501-510
5. Mei Hong Zhu, In Kyung Sung, Haifeng Zheng, Tae Sik Sung, Fiona C. Britton, Kate O'Driscoll, Sang Don Koh and Kenton M. Sanders. Muscarinic activation of Ca^{2+}-activated Cl^- current in interstitial cells of Cajal. J Physiol 589.18 (2011) pp 4565–4582
6. Jun Lee, Young Dae Kim, Chan Guk Park, Man Yoo Kim, In Yeoub Chang, Dong Chuan Zuo, Pawan Kumar Shahi, Seok Choi, Cheol Ho Yeum, and Jae Yeoul Jun. Neurotensin Modulates Pacemaker Activity in Interstitial Cells of Cajal from the Mouse Small Intestine. Mol. Cells 33, 509-516, May 31, 2012
7. Pablo Garcia-Lopez , Virginia Garcia-Marin and Miguel Freire. The histological slides and drawings of Cajal. Frontiers in Neuroanatomy March 2010, Volume 4, Article 9, 1-16
8. Dengqun Liu, Fengchao Wang, Zhongmin Zou, Shiwu Dong, Junping Wang, Xinze Ran, Chunxue Li, Chunmeng Shi, and Yongping Su. Bone Marrow Derivation of Interstitial Cells of Cajal in Small Intestine Following Intestinal Injury. Journal of Biomedicine and Biotechnology Volume 2010, Article ID 164986, 9 pages doi:10.1155/2010/164986
9. L. M. Popescu, Maria-Simonetta Faussone-Pellegrini. TELOCYTES – a

case of serendipity: the winding way from Interstitial Cells of Cajal (ICC), via Interstitial Cajal-Like Cells (ICLC) to TELOCYTES J. Cell. Mol. Med. Vol 14, No 4, 2010 pp. 729-740

10. Hanne B. Mikkelsen. Interstitial cells of Cajal, macrophages and mast cells in the gut musculature: morphology, distribution, spatial and possible functional interactions J. Cell. Mol. Med. Vol 14, No 4, 2010 pp. 818-832
11. Jan D. Huizinga, Natalia Zarate, and Gianrico Farrugia. Physiology, injury and recovery of interstitial cells of Cajal: basic and clinical science. Gastroenterology. 2009 November ; 137(5): 1548–1556.
12. Randa M Mostafa, Yasser M Moustafa, Hosam Hamdy. Interstitial cells of Cajal, the Maestro in health and disease. World J Gastroenterol 2010 July 14; 16(26): 3239-3248
13. Stefan Gfroerer, Roman Metzger, Henning Fiegel, Priya Ramachandran, Udo Rolle. Differential changes in intrinsic innervation and interstitial cells of Cajal in small bowel atresia in newborns. World J Gastroenterol 2010 December 7; 16(45): 5716-5721
14. Vesna Janevska, Adelina Qerimi, Neli Basheska, Elena Stojkova, Vlado Janevski, Rubens Jovanovic, Julija Zhivadinovik, Liljana Spasevska. Superficial leiomyomas of the gastrointestinal tract with interstitial cells of Cajal. Int J Clin Exp Pathol 2015;8(12):15977-15984
15. Jerry Gao, Shameer Sathar, Gregory O'Grady, Juan Han, and Leo K Cheng. Numerical metrics for automated quantification of interstitial cell of Cajal network structural properties. J R Soc Interface 10: 20130421.
16. Zhi-Hua Chen, Yong-Chang Zhang, Wei-Fang Jiang, Cissy Yang, Gang-Ming Zou, Yu Kong, Wei Cai. Characterization of Interstitial Cajal Progenitors Cells and Their Changes in Hirschsprung's Disease. PLoS ONE 9(1): e86100. doi:10.1371/journal.pone.0086100
17. Wojciech Apoznanski, Piotr Koleda, Zdzislaw Wozniak, Leslaw Rusiecki, Tomasz Szydelko, Dariusz Kalka, Witold Pilecki. The distribution of interstitial cells of Cajal in congenital ureteropelvic junction obstruction. Int Urol Nephrol (2013) 45:607–612
18. Jonas Wixner, Konen Obayashi, Yukio Ando, Pontus Karling, and Intissar Anan. Loss of gastric interstitial cells of Cajal in patients with hereditary transthyretin amyloidosis. Amyloid, 2013; 20(2): 99–106
19. Maria-Simonetta Faussone-Pellegrini, Camillo Cortesini and Paolo Romagnoli. The ultrastructure of the muscle coat of human gastro-oesophageal junction, with special reference to"interstitial cells of Cajal". Frontiers in Neuroscience. April 2013, Volume 7, Article 49, 1-8

