
Role of Hydrosonography of the small bowel in the detection of Inflammatory Bowel Disease & Small Bowel Tumors

Thesis Submitted for partial fulfillment of the Master Degree of Internal Medicine
By

Dr. Mahmoud Wahba Elbiuly
MBBCh , Kasr Al-Ainy Faculty of Medicine - Cairo University

Supervised by

Prof. Dr. Hussein Hassan Okasha
Professor of Internal Medicine, Kasr Al-Ainy Faculty of Medicine - Cairo University

Prof. Dr. Mai Mohsen Fawzi
Professor of Internal Medicine, Kasr Al-Ainy Faculty of Medicine - Cairo University

Dr. Ali Hassan Farag
Lecturer of Internal Medicine, Faculty of medicine - Cairo University



**Faculty of Medicine
Cairo University
2015**



Acknowledgements

First and for most, I feel always indebted to **Allah**, the most kind and the most merciful.

This work was carried out during the April - October 2015 at the Internal Medicine Hospital, at the Department of Internal Medicine - Cairo University.

I owe my deepest gratitude to my advisor Professor Dr. **Hussein Hassan Okasha**, Without his continuous optimism concerning this work, enthusiasm and support this study would hardly have been completed.

And my sincere thanks also goes to my supervisor Professor Dr. **Mai Mohsen Fawzi**, I am heartily thankful for her encouragement, guidance and support from the initial to the final level which enabled me to develop an understanding of the subject.

I also express my warmest gratitude to my supervisor

Dr. **Ali Hassan Farag**, for the continuous support of my research, for his patience, motivation, and immense knowledge. His guidance into the world of Hydrosonography and supervision in data analysis has been essential during this work.

Their guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisors and mentors for my thesis.

My sincere thanks also goes to Dr. Mahmoud Ahmed AbdelMageed, Without his precious support it would not be possible to conduct this research.

Completion of this thesis would not have been possible without the help of the Patients affected with inflammatory bowel disease and their families, to whom I am profoundly grateful, for allowing us to conduct this thesis in the pursuit of research activities, with the aim of enhancing their lives or those of future patients who will be afflicted with this disease.

Thanks to the subjects who voluntarily participated in the study, none of this would have been possible without them. Their dedication and perseverance made for an enjoyable six months.

Last but not the least,

I would like to thank my family and to my fiancée Ghada Mahmoud Habib, for supporting me spiritually throughout writing this thesis.

Words cannot describe how lucky I am to have you in my life.

Abstract

Mahmoud W. Elbiuly, internal medicine resident, faculty of medicine, Cairo university

Abstract of Master's Thesis, Submitted October 2015:

Role of Hydrosoneography of the small bowel in the detection of Inflammatory Bowel Disease & Small Bowel Tumors

The aim of this thesis is to determine the diagnostic accuracy of hydrosoneography as an initial method in diagnosis of inflammatory bowel disease and small bowel tumors.

Hydrosoneography have been successfully used to diagnose of gynecological and obstetrical disease.

The role of hydrosoneography of the small bowel has become increasingly important in the diagnostic workup and medical decision making for the small bowel disorders, both in acute and non-acute conditions.

Recently bowel ultrasonography is now becoming the first-line imaging procedure in patients with suspected Crohn's Disease for early diagnosis of the disease, and assessing patients suspected small bowel tumors.

This study was conducted in Egypt, sixty patients suspected bowel disease, hydrosoneography was done to all patients. Upper endoscopy and colonoscopy, serology or imaging necessarily to reach the final diagnosis.

The results of the thesis show that hydrosoneography is important in the diagnostic workup in patients with suspected Inflammatory bowel disease for early diagnosis and suspicion of small bowel tumors.

Key Words: chronic diarrhea, chronic abdominal pain, bowel hydrosoneography, inflammatory bowel disease, small bowel tumors.

■ List of Content :

I. Introduction & Aim of Work	Page 1
II. Review	Page 4
1- Sonographic anatomy of the bowel	Page 5
Normal ultrasound anatomy	Page 5
Normal sonographic bowel wall anatomy	Page 7
Mesenteric lymph nodes	Page 11
2- Hydro-Sonography	Page 12
Normal bowel ultrasound	Page 12
Hydrosonography of the Small Intestine	Page 13
Hydrocolonic Sonography	Page 19
3- Inflammatory Bowel Disease	Page 21
Definitions	Page 21
Epidemiology	Page 21
Pathogenesis	Page 22
Diagnosis of IBD in adult patients	Page 24
Management of IBD	Page 31
Management of extra-intestinal manifestations of IBD	Page 37
Recommended vaccinations for IBD patient	Page 38
4- Small Bowel Tumors	Page 39
Introduction	Page 39
Tumor Site	Page 39
Mode of Presentation	Page 40
Diagnosis & Treatment	Page 41
5- Sonographic Manifestations of Crohn's disease (CD)	Page 42
Advantages of US in inflammatory bowel diseases	Page 42
Value of sonography in crohn's disease	Page 42
Indications for bowel US in crohn's disease	Page 43
Sonographic features of crohn's disease	Page 43
Abdominal Complications of crohn's disease	Page 50
6- Sonographic Manifestations of Ulcerative Colitis (UC)	Page 56
Indications and potential usefulness of bowel ultrasound in UC	Page 56
Detection and Assessment of Extension	Page 60
7- Sonographic Manifestations of Small Bowel Tumors	Page 63
Preparations for Sonographic Assessment of Submucosal Tumors	Page 64
II. Methodology	Page 70
IV. Results	Page 74
V. Discussion	Page 89
VI. Summary & Conclusion	Page 95
VII. References	Page 96
VIII. Arabic summary	Page 118

■ List of abbreviations :

AO	Abdominal Aorta
BWT	Bowel Wall Thickness
CBC	Complete Blood Count
CD	Crohn's Disease
CDAI	Crohn's Disease Activity Index
CT scan	Computerized Tomography scan
ESR	Erythrocyte Sedimentation Rate
EUS	Endoscopic UltraSound
IBD	Inflammatory Bowel Disease
IBDU	Inflammatory Bowel Disease Undetermined
IBS	Irritable Bowel Syndrome
IC	Intermediate Colitis
IMA	Inferior Mesenteric Artery
pANCA	p-AntiNeutrophil Cytoplasmic Antibodies
PEG	PolyEthylene glycol
PET	Positron Emission Tomography
PV	Portal Vein
SICUS	Small Intestine Contrast Ultrasonography
SMA	Superior Mesenteric Artery
SMT	Small Bowel Tumors
Th-1	T-helper-1 cells
Th-2	T-helper-2 cells
UC	Ulcerative Colitis
US	UltraSound

■ List of Tables :

[Table. 1]	Sonoanatomy of the normal intestinal wall	Page 9
[Table. 2]	Definition of Crohn's disease phenotype according to the Montreal classification ...	Page 21
[Table. 3]	Diagnosis of ulcerative colitis (UC) and Crohn's disease (CD)	Page 29
[Table. 4]	World Health Organization diagnostic criteria for Crhon's disease	Page 30
[Table. 5]	Disease activity in ulcerative colitis	Page 30
[Table. 6]	Features for differentiating (UC) and (CD)	Page 31
[Table. 7]	the control of the study	Page 74
[Table. 8]	Demographic features of the studied group	Page 75
[Table. 9]	sex distribution in the studied group	Page 76
[Table. 10]	Distribution of the lesions at different bowel segments & their percentage	Page 78
[Table. 11]	distribution of the lesions at different bowel segments & their percentage	Page 79
[Table. 12]	Segment site & their percentage	Page 80
[Table. 13]	luminal diameter & their percentage	Page 80
[Table. 14]	bowel wall stratification	Page 81
[Table. 15]	Bowel Wall Compressibility	Page 82
[Table. 16]	Bowel Wall Motility	Page 82
[Table. 17]	Correlation between Hydrosonographic Diagonsis & Final Diagnosis	Page 84
[Table. 18]	Diagnostic Efficacy of Hydrosonography in IBD & Small Bowel Tumors	Page 85
[Table. 19]	Diagnostic statistics of the study	Page 85

■ List of Figures :

[Fig. 1]	Sonographic identification of the colon	Page 6
[Fig. 2]	Sonomorphology of small bowel loops	Page 8
[Fig. 3]	Sonomorphology of large bowel loops	Page 9
[Fig. 4]	Hydrosography of normal bowel wall	Page 9
[Fig. 5]	Normal appendix	Page 10
[Fig. 6]	Normal appendix	Page 10
[Fig. 7]	Ultrasonographic appearance of normal lymph nodes	Page 11
[Fig. 8]	A mildly enlarged rt. lower quadrant lymph nodes	Page 11
[Fig. 9]	Yersinia lymphadenitis & Malignant lymphoma	Page 11
[Fig. 10]	US of small bowel	Page 14
[Fig. 11]	Normal segments of the small intestine visualized by hydrosography	Page 14
[Fig. 12]	Normal hydrosography of the terminal part of ileum & the ileocaecal valve	Page 14
[Fig. 13]	The hydrosographic appearance of Crohn's disease in the distal part of ileum	Page 17
[Fig. 14]	Cross-sectional image of small intestine hydrosography in Crohn's disease	Page 17
[Fig. 15]	CD lesions of small intestine well delineated by means of oral contrast US	Page 18
[Fig. 16]	Crohn's disease stricture of terminal ileum	Page 18
[Fig. 17]	Key features of the intestinal immune system.	Page 23
[Fig. 18]	gastric gastrointestinal stromal	Page 39
[Fig. 19]	US of colon segment in Crohn's disease	Page 45
[Fig. 20]	Thickening of the appendix in Crohn's disease	Page 45
[Fig. 21]	Crohn's disease echo pattern	Page 46
[Fig. 22]	Crohn's disease echo pattern	Page 46
[Fig. 23]	Cross-sectional image of small intestine hydrosography in Crohn's disease	Page 47
[Fig. 24]	The hydrosographic appearance of Crohn's disease in distal part of ileum	Page 47
[Fig. 25]	Ileal Crohn's disease	Page 47
[Fig. 26]	The increased vascularity within the bowel wall in CD	Page 49
[Fig. 27]	Crohn's disease echo pattern	Page 49
[Fig. 28]	Mesenteric lymphadenopathy in early ileal and jejunal Crohn's disease	Page 50
[Fig. 29]	Acute stenosis within the lumen of the proximal loop	Page 51
[Fig. 30]	hypoechoic echo pattern at level of the stenosis and prestenotic dilatation	Page 51
[Fig. 31]	US appearance of internal fistulae	Page 53
[Fig. 32]	US fistulography	Page 53
[Fig. 33]	Large Crohn's abscess containing gas	Page 54
[Fig. 34]	Crohn's disease echo pattern	Page 54
[Fig. 35]	Intra-abdominal abscesses	Page 55
[Fig. 36]	Ultrasonographic features of bowel wall in patient with ulcerative colitis	Page 55
[Fig. 37]	Longitudinal U/s sections of descending colon	Page 58
[Fig. 38]	Ultrasonographic features of pancolitis	Page 59
[Fig. 39]	Ultrasonographic aspect of bowel wall in patient with active ulcerative colitis	Page 60
[Fig. 40]	Severe active UC showing severely thickened and hypoechoic bowel walls	Page 61
[Fig. 41]	Ultrasonographic findings in UC patient with pseudopolyposis	Page 61
[Fig. 42]	Quiescent UC	Page 62
[Fig. 43]	Sonographic feature of a gastric carcinoid	Page 63
[Fig. 44]	Endoscopic feature of rectal carcinoid	Page 63
[Fig. 45]	Endoscopy of a gastric cyst	Page 64
[Fig. 46]	Lymphangioma at the duodenal bulb	Page 65
[Fig. 47]	Aberrant pancreas at the greater curvature of the stomach	Page 66

[Fig. 48]	Endoscopic ultrasound of a gastric hemangioma	Page 67
[Fig. 49]	Sonography of the jejunal GIST	Page 67
[Fig. 50]	Sonography of a gastric schwannoma with massive central necrosis	Page 68
[Fig. 51]	Sonography of the inflammatory fibroid polyp in the ileum	Page 68
[Fig. 52]	Extramural compression of the gastric wall by the spleen	Page 69
[Fig. 53]	Age distribution in the studied group	Page 75
[Fig. 54]	Gender distribution in the studied group	Page 76
[Fig. 55]	Indication distribution in the studied group	Page 77
[Fig. 56]	Prevalence of lesions by bowel hydrosonography at different segment	Page 78
[Fig. 57]	Extend of the affected segments	Page 79
[Fig. 58]	percentage of patients with thick wall	Page 80
[Fig. 59]	luminal diameter & their percentage	Page 81
[Fig. 60]	Number of bowel loop with lost stratifications	Page 81
[Fig. 61]	Diagnostic distribution of the cases in the study	Page 83
[Fig. 62]	Correlation between Hydrosonographic Dx. of Crohn's Disease & its Final Dx.	Page 84
[Fig. 63]	Correlation between Hydrosonographic Dx. of Crohn's Disease & its Final Dx.	Page 84
[Fig. 64]	Diagnostic statistics of the study	Page 85
[Fig. 65]	Hydrosonography shows Irregular thickening of duodenal mucosa, third part.....	Page 86
[Fig. 66]	Entroscopy of the duodenal shows circumferential mass of the third part.....	Page 86
[Fig. 67]	Hydrosonography shows narrow lumen of the duodenal , third part.....	Page 86
[Fig. 68]	thick duodenal mucosa with loss of stratification duodenal mucosa, third part.....	Page 86
[Fig. 69]	hydrosonography shows thick terminal ileum with loss of stratification.....	Page 87
[Fig. 70]	hydrosonography shows thick terminal ileum.....	Page 87
[Fig. 71]	ct abdomen small bowel thickening	Page 88
[Fig. 72]	hydrosonography shows thick terminal ileum with loss of stratification	Page 88
[Fig. 73]	hydrosonography marked thickening of terminal ileum with target sign	Page 88
[Fig. 74]	Endoscopy showed marked narrow terminal ileum	Page 88

■Introduction:

Abdominal ultrasonography is a great way to examine abdominal organs. It's readily available, portable, cheap and non-invasive. If we distend the bowel loops with an oral non-absorbable fluid, the bowel loops can be examined with ultrasonography as well. This method of examination is called hydrosonography. Bowel US can be improved by filling the bowel with water or echo-poor liquids, either directly infused into the small bowel using a nasal-jejunal tube and a peristaltic pump, or administered orally. In both cases, the liquid contrast medium should be non-absorbable and non-fermentable.

IBD is a chronic disease with remission and exacerbation and variable response to therapy needing repeated evaluation. A non-invasive tool of diagnosis would be of great value in the evaluation and follow up of such patients. Ultrasound and color Doppler were reported to be of promising value to attain such objective (**Wilson, 2011**).

Advances in the understanding of bowel appearances with high resolution sonography have led to consideration of this technique as an important tool for bowel disease assessment. Ultrasonography may display the transformation of the intestinal wall from normal to pathological state in inflammatory disease. Furthermore, intestinal ultrasonography may serve as a diagnostic clue if typical patterns of the bowel wall are demonstrated (**Allygar et al., 2011**).

Abdominal sonography as a non-invasive diagnostic method has proven to be of great value in evaluating patients with acute and chronic IBD. The ultrasound pattern of bowel inflammation is characterized by thickened and hypoechoic inflamed bowel wall (**Nylund et al, 2009**).

Hydrosonography is a useful procedure in screening for intra-cavitary pathologies and allows differentiation of intra-cavitary, endometrial, and submucosal abnormalities (**Guyen, 2004**).

Hydrosonography has become increasingly important in the diagnostic work-up and medical decision making for gastrointestinal disorders, both in acute and non-acute conditions. Recently bowel ultrasonography is becoming the first-line imaging procedure in patients with suspected CD for early diagnosis of the disease (**Parente, 2004**).

Similarly, color Doppler can be used as a non-invasive method to evaluate the vascular changes which develop in splanchnic circulation and the bowel wall of patients with IBD. Thickened and hypervascularized bowel wall is characteristic findings in IBD. Power Doppler sonography offers an additional non-invasive procedure for the determination of activity in patients with IBD (**Hagiu & Radu, 2007**).

Color Doppler can identify increased vascularity associated with gastrointestinal inflammatory conditions. It has been suggested that specific diagnosis can be established based on flow patterns. Mucosal or transmural hypervascularity on color Doppler can be seen with several inflammatory bowel processes (***Homann et al, 2005***).

Doppler can demonstrate splanchnic hemodynamic changes in active IBD patients and can be used to differentiate between active and quiescent cases (***Maconi et al., 2002***).

■Aim of Work:

The aim of this study is to determine the diagnostic accuracy of hydrosoneography as an initial method in diagnosis of inflammatory bowel disease and small bowel tumors.

■ **Review :**

- 1- **Sonographic Anatomy of the Bowel.**
- 2- **Hydro-Sonography.**
- 3- **Inflammatory Bowel Disease.**
- 4- **Small Bowel Tumors.**
- 5- **Sonographic Manifestations of Crohn's disease (CD).**
- 6- **Sonographic Manifestations of Ulcerative Colitis (UC).**
- 7- **Sonographic Manifestations of Small Bowel Tumors.**

1- Sonographic anatomy of the bowel

■ Normal ultrasound anatomy;

① Duodenum :

The duodenal bulb follows the pyloric stricture. The second duodenum descends vertically at the contact of the gallbladder and surrounding the pancreas head. Duodenum patterns are variable and should not be confused with pathological collections. A prolonged observation will show filling and emptying movements. The third duodenum is visible between the aorta and the superior mesenteric artery (*Lichtenstein, 2005*).

② Small Bowel :

It is almost always possible to visualize at least some loops of the small bowel (*Lichtenstein, 2005*).

Small intestinal loops are in the midabdomen, Small bowel loops can be recognized by the presence of valvulae conniventes when the lumen is filled with fluid (*O'Malley and Wilson, 2003*).

The jejunum is recognized by the endoluminal presence of villi. The ileum has a tubular, regular pattern (*Lichtenstein, 2005*).

Acute disorders of the bowel affect the whole of the bowel. Consequently, ultrasound analysis of an even small portion can be rich in information. Many relevant items can be extracted:

1. Peristalsis gives a permanent crawling dynamics, with regular contractions. A present peristalsis can be objectified in a few seconds. This is the usual pattern in the normal subject. Prolonged observation (at least 1 min) seems necessary to affirm abolition of peristalsis.
2. The normal caliper of the small bowel is approximately 12–13 mm.
3. Contents can have either a homogeneous echoic or hypoechoic pattern.
4. Wall thickness ranges from 2 to 4 mm. Fine analysis of the wall is greatly facilitated when there is liquid contrast from both sides, i.e., peritoneal effusion associated with fluid content, two conditions often present in acute disorders (*Lichtenstein, 2005*).

The terminal ileum is very often, resting on top of the psoas muscle. It can be followed distally to the cecum. The small intestine is recognized by the presence of motility and mucosal folds (plicae circulares). It also has a tortuous course, contains air, and is easily compressible; the jejunum has slightly more mucosal folds and a larger diameter than the ileum. Another marker; the jejunum is mainly located in the umbilical region, whereas the ileum is mainly in the hypogastrium and the pelvic area (*Nylund et al., 2010*).

③ The colon :

The colon is a tubular structure with visible haustra, without identifiable peristalsis. Roughly, the ascending and descending colon are vertical structures located in the flanks, the transverse colon is horizontal at the epigastric level and distinct from the stomach (*Lichtenstein, 2005*).

The colon is located in the periphery of the abdomen with the cecum and ascending colon laterodorsally on the right side of the abdomen and the descending colon laterodorsally on the left side. The right colonic flexure is usually found just behind the lower portion of the right liver lobe and the splenic flexure just below the spleen. The location of the transverse and the sigmoid colon may vary significantly due to the varying length of their mesocolon. The watershed between the two visceral arteries is in the distal transverse colon near the splenic flexure which explains the distribution of affected colonic segments in ischemic disease (*Hollerweger, 2007*).

To examine the colon, the examiner returns to the right iliac fossa and follows the ileum to the cecum. The appendix can be identified as a structure leaving the cecum and ending, It is frequently seen lying between the terminal ileum and the right psoas muscle (*Nylund et al., 2010*).

On US, the colon is characterised by its typical haustration (*O'Malley and Wilson, 2003*). The right hemicolon is usually filled with stool and gas whereas the left hemicolon is often seen in a contracted condition [Fig. 1]. The diameter of the colon usually measures up to 5 cm, whereas that of the cecum may exceed this width (*Hollerweger, 2007*).



[Fig. 1] Sonographic identification of the colon.

The longitudinal section of the normal ascending colon (a) shows the typical haustration pattern. The bowel wall is very thin and barely visible. On a cross-section of the contracted sigmoid colon on its course over the iliac vessels (b) the different bowel wall layers are visible (c) normal transverse colon is seen in a longitudinal section with obvious haustra. The fecal matter is mixed with gas (*Hollerweger, 2007*).

④ Appendix :

In a healthy person, the appendix is usually not visible during the sonographic screening. Nonetheless, in a very small percentage of patients, a normal appendix is visible with sonography. The appendix arises from the site at which three taenia unite and varies considerably in length and width, averaging 5 to 10 cm in length. It is usually curved and maybe tortuous (**Chen, 2005**). The position of the appendix is highly variable. Antrocaecal position or a position within the small pelvis may be found (**Gritzmann, 2007**).

The normal appendix can be differentiated from the small bowel loops by the absence of peristalsis and intraluminal chylous flow and lack of changes in configuration over time (**Chen, 2005**).

■ Normal sonographic bowel wall anatomy;

• Sonoanatomy of bowel wall;

Histologically, the bowel wall is comprised of several distinct layers. These layers include (i) the mucous membrane, which is made up of the epithelium, lamina propria, and muscularis mucosa; (ii) the submucosa; (iii) the muscularis propria, which is made up of the inner circular layer and the outer longitudinal layer; and (iv) the serosa (**Nino-Murcia and Jeffrey, 2008**).

On routine transabdominal scanning, the normal bowel may appear as a collapsed structure with an echogenic center and a hypoechoic bowel wall surrounded by a more echogenic peripheral zone. However, this appearance varies, depending on which portion of the gastrointestinal tract is identified and whether the bowel is collapsed or fluid filled. When the bowel is fluid filled, it appears as an echogenic wall surrounding the central fluid-filled lumen. Occasionally, discrete layers of the bowel wall may be identified on transabdominal scanning. However, with transducers in the 3.5 to 6 MHz range, the most prominent feature of the normal bowel is often the echogenic submucosal layer (**Nino-Murcia and Jeffrey, 2008**).

High resolution transducers usually permit visualization of the five layers of the intestine and stomach walls (**Dietrich et al., 2007**).

These include three echogenic layers and two hypoechoic layers. The different layers with their histologic correlations include (i) the echogenic superficial mucosa, including the luminal contents and the mucosal inner face; (ii) the hypoechoic, deep mucosa, which also includes the muscularis mucosa; (iii) the echogenic submucosa, which includes the interface between the submucosa and the muscularis propria; (iv) the hypoechoic muscularis propria; and (v) the echogenic serosa, which includes the serosal surface and the serosal fat (**Nino-Murcia and Jeffrey, 2008**). The GI wall has a normal stratification if five US layers are visible, and