
Jacques W.A.J. Reenders

Academic Medical Center, Amsterdam, the Netherlands

Gastrointestinal Radiology as we consider nowadays, has its true beginning less than a year after the discovery of a new type of rays by Wilhelm Konrad Roentgen in November 1895. In early December 1896, Walter Bradford Cannon and Albert Moser began their fluoroscopic studies on esophageal motility followed by an American radiologist Francis Henry Williams and German, Viennese and Swedish radiologists, who developed new advance techniques for gastrointestinal examinations. The modern examinations of the alimentary tract are the product of a combination of the Japanese and German school.

From its very beginning, gastrointestinal radiology was at the forefront of radiology, combining physiologic and anatomic information. From evaluation of esophageal motility to the first depiction of gastric ulcers and carcinomas of the alimentary tract, gastrointestinal radiology became indispensable to physicians/surgeons. Improvements were made in fluoroscopic and radiologic equipment (e.g. tilting table), the image intensifier, development of selective visceral angiography with safer contrast materials, and more recently, digital substraction angiography, digital Ultrasound (US), Colour Doppler Ultrasound, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). All of these newer modalities have made establishment of a diagnosis by radiological imaging more precise and safer. The choice of radiological examination should be specific for a given diagnosis. They should provide maximal information of the full extent of the disease process. This information should be translated into improved patient management. Plain film identification of intraperitoneal structures is generally limited to those aspects outlined by contrasting extraperitoneal fat or intraluminal gas. Fibre-optic endoscopy and barium studies provide direct information about the mucosal lining. A major limitation has been the inability to accurately evaluate the thickness of bowel wall. In these circumstances, only indirect signs are relied upon in the diagnosis of mural or serosal disease. However, Computed Tomography (CT) - in addition - may image the intra-mural, mural and serosal abnormalities giving information about the extravisceral adjacent structures.

CT, due to its superior density discrimination and excellent spatial resolution, permits exquisite imaging of the gastrointestinal tract, mesenterial structures and peritoneal cavity. This is clinically important for those gastrointestinal tract abnormalities which extend beyond the mucosa e.g. diverticulosis, inflammatory bowel disease and gastrointestinal malignancies. Cross-sectional modalities have rapidly been adapted to the alimentary tract and have greatly contributed to the "gastrointestinal imaging". On every CT image of the abdomen portions of the gut are visualised. So specific evaluation of the bowel should be included in the interpretation of these examinations. Increased experience of both performing and interpreting CT studies, combined with increasing use of high resolution (helical) CT scanners, and the use of safer contrast materials have led to the maturity of the CT to become a vital diagnostic modality and a highly sensitive tool in the evaluation of digestive abdominal abnormalities.

Although CT is established as one of the most important techniques for imaging the gastrointestinal tract (GIT), it should be used selectively and only on the basis of conventional radiologic examinations.

Indications
The indication and accuracy of CT of the GIT have been dramatically enlarged and improved today. It is based on CTS usefulness for:

- diagnosing or suggesting the presence of primary gut disease
- evaluating the nature, extent of disease in patients with known GIT lesions.
- determining the presence, location and severity of complications associated with primary GIT lesions.
Conventional barium examinations remain superior to CT for evaluating intraluminal and mucosal disease.

CT is far more accurate for evaluating the intramural and extraintestinal components including involvement of the mesentery, peritoneal cavity, retroperitoneal and solid organs.

Contrast studies should be performed in all patients in whom the presence, origin or nature of abnormality is unknown or uncertain at time of CT examination. Conversely, CT examinations are often required to elucidate and evaluate gastrointestinal abnormalities detected or suspected on conventional examinations.

Technical Considerations
Routine abdominal CT examinations are inadequate for evaluation of specific GIT abnormalities; therefore special efforts need to be taken to visualize such an abnormality, which can be summarised as follows:

- Adequate bowel preparation is essential for accurate evaluation of the true thickness of the bowel wall of the GIT. It should be empty, clean and the lumen opacified and distended.
- Administration of proper amount of the oral contrast media.
- Changing the patient’s position on the table to the prone, or lateral decubitus may also enhance the visualisation of such an abnormality.
- Imaging of primary GIT lesions should be done whenever possible during the arterial phase after a bolus of IV contrast and using the spiral CT technique.
- High resolution images with thin 5mm slice thickness at the pathologic area suspected. Inf IV glucagon can be administered to inhibit peristalsis.

Common Pitfalls in CT Interpretation
Interpretation of any given study is potentially subjected to various pitfalls. Most of the pitfalls in the CT detection and evaluation of GIT lesions are related to technical failures. Inadequate contrast filling of the intestinal lumen and incomplete distension during CT scanning are the most common causes. An empty, collapsed or fluid-filled bowel can present as soft tissue density mimicking mesenteric tumours which “pseudotumours” may be located throughout the intestinal tract. Very commonly the normal esophago-gastric junction assumes a mass-like appearance because of the oblique course of the distal esophagus before it enters the cardia. The knowledge of this fact will prevent misinterpretation of a normal anatomic structure as a “mass”. In case of suspicion, an extra dose of oral contrast agent can be ingested in the prone position. So, “pseudomasses” (e.g. fundal diverticulum) can be eliminated from the differential diagnosis.

Partial filling of the intestinal lumen can also lead to “false positives” or “false negatives” because of the inability to determine the true thickness of the gastrointestinal wall.

Another cause is partial distension of the bowel. On CT the normal thickness varies with the degree of bowel distension. The bowel wall is 1-2mm thick in a distended bowel and 3-4 mm in a collapsed or partially distended bowel. If the wall appears concentrically, symmetrically thickened with a homogeneous enhancement the clinical significance of this finding should be taken with caution, for it has to be related to the degree of bowel distension.

Parameters for CT Evaluation
Once a lesion is detected its radiologic features are analysed by criteria similar to those employed in conventional radiology as the:

* location of the abnormality
* size of the lesion
* length of affected segment.

They may be defined as affecting a certain segment of the GIT focally, segmentally or diffusely.

Other important CT criteria to be considered are:

* Degree of wall thickness
* Symmetry
* Smooth or irregular margins
* Contour and lobulation
* Pattern of enhancement after a bolus of i.v. contrast injection
* Exophytic growth
Associated lymph node enlargement
* Adjacent mesentery

Benign lesions are characterised by:
* Circumferential thickening of the bowel wall (<1cm)
* Symmetrical involvement
* Segmental or diffuse involvement
* Adjacent inflammatory reaction into mesentery appearing as thickened and streaky densities
* Homogenously enhancing wall after i.v. contrast injection

"Double halo" and "target" signs
These CT signs may be present, when there is submucosal oedema, inflammation and/or fat deposition at the bowel. It is helpful in differential diagnosis between benign and malignant disease. These "ring densities" are better appreciated during the arterial phase of contrast enhancement

These signs may be seen in the following pathologies of GIT:
* ischemic enteritis
* Crohn's disease
* ulcerative colitis
* radiation enteritis
* bowel edema
* infectious colitis
* secondary to pancreatitis

According to bowel wall enhancement after i.v. contrast injection, they are either:

Hyperattenuated as seen in:
- scirrhous carcinoma
- Crohn's disease
- acute appendicitis
- ischaemia

Hypoattenuated as seen in:
- oedema
- fat
- mucin

Inflammatory bowel disease is characterised by:
- symmetrical bowel wall thickening
- segmental distal ileal loop distribution
- skipped areas of involvement
- fistulas
- fibrofatty proliferation of the mesentery which appear as various degrees of streaky and poorly defined heterogeneous fat densities
- abscess formation(s).

All these signs may be seen continuously or separately in Crohn's disease. Mucosal abnormalities are best appreciated by endoscopy or double contrast barium studies.

In other inflammatory diseases as ulcerative colitis and ischemic colitis, CT may be of value in severe forms and are characterised by:
- diffuse distribution
- marked concentric thickening of the bowel wall.
- deep transmural ulcerations.
- pericolic inflammatory changes.

Intestinal Ischaemia
Intestinal ischaemia may have CT features, similar to those seen in Crohn's disease as:

* segmental distribution.
* symmetrical, circumferential thickening of the affected bowel wall.
* intramural haemorrhage appearing as high density wall thickening.
* mesenteric blood may be seen.

Because it is non-invasive, highly sensitive examination for the entire peritoneal cavity, pelvis and retroperitoneum, CT has become the imaging technique of choice. Recently MRI has the upper hand in patients with bleeding tendency due to abnormal clotting factors.

It can sometimes establish the cause of ischaemia by showing arterial occlusion or thrombosis of the SMA or portal veins. In advanced stages of bowel ischaemia infarction has already developed with air in the wall (pneumatosis) and/or air in the regional mesenteric venous system.

Radiation enteritis may have similar CT features as ischaemia and can be properly diagnosed from the clinical history.
Neoplastic thickened wall is characterised by:

* Eccentric and asymmetrically thickened bowel wall (>2cm)
* Irregular and lobulated outline.
* Abrupt transition between normal and abnormal wall.
* Narrowing of the bowel lumen.
* Regional lymphadenopathy.
* Distant metastases.
* Homogeneous or heterogeneous pattern of enhancement after I.V. contrast injection.

Signs which may differentiate benign from malignant bowel wall thickening (own studies) may be summarised as follows:

<table>
<thead>
<tr>
<th>Symmetric wall thickening</th>
<th>Benign</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetric wall thickening</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Nodular thickening</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>More than 1 cm</td>
<td>+/-</td>
<td>+</td>
</tr>
<tr>
<td>“Target sign”</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Primary Adenocarcinoma of the GIT are characterised by the following CT features:

* involves stomach and colon most commonly
* the small bowel is an uncommon location and involves the proximal duodenojejunal segment mainly.
* short bowel segment is involved most often.
* the mass is mostly eccentric focally.
* circumferential asymmetric thickening is common.
* irregular outline.
* wall thickness often more than 2cm.
* heterogenous enhancement of the tumorous lesion, after I.V. contrast injection.

Lymphoma: most common CT findings:

* mural soft tissue mass lesion
* concentric wall thickening
* longer segment of bowel involved
* lobulated outline
* sharp margins

* homogeneous density
* enlargement of regional lymph nodes ulceration

Leiomyosarcoma: most common CT findings:

* bulky tumour
* large lobulated exophytic soft tissue mass
* central necrosis
* when liquified it appears as fluid-fluid cyst.

References