Nonsteroidal anti-inflammatory drug (NSAID)-induced enteropathy is an increasingly recognized entity. Patients of older age and those suffering from conditions such as arthritis requiring long term NSAIDs are thought to be at greater risk. Introduction of enteroscopic techniques has greatly improved understanding of NSAID-related small intestinal injury. Complementary high-resolution cross-sectional imaging techniques aid in initial evaluation and for exclusion of alternative etiology. Erosions, superficial ulcerations, and short segment strictures are the most commonly described findings. The diagnosis of the condition lies in obtaining relevant history in addition to a high degree of suspicion during investigation of anemia, obscure gastrointestinal bleeding, small bowel obstruction, and protein losing enteropathy. Herein, the authors present a review of pathogenesis and imaging findings of NSAID enteropathy with particular emphasis on distinction from Crohn’s enteropathy.

Abstract

Keywords
- computed tomography enterography
- Crohn’s disease
- diaphragm disease
- enteropathy
- enteroscopy
- magnetic resonance enterography
- nonsteroidal anti-inflammatory drugs
- small intestine
- stricture

Introduction

Nonsteroidal anti-inflammatory drugs (NSAIDs) are one of the most widely prescribed medications. More than 100 million prescriptions are written in United States annually and approximately 50 billion aspirin tablets are consumed worldwide. The gastrointestinal (GI) tract appears to be the most commonly affected organ by chronic long-term use. The worldwide prevalence of NSAID-associated gastric or duodenal ulcers ranges from 9 to 22%, with severe hemorrhage and obstruction occurring in less than 1% of patients. It is thought that use of enteric coated, sustained release or slow release NSAIDs may have shifted the damage from more proximal areas of the GI tract towards the distal small intestine and even the colon. Lanas et al reported this shift as a ratio of gastroduodenal to distal involvement that changed from 4:1 in 1996 to 1:4 in 2005. In an autopsy series by Allison et al, small intestinal erosions were found in 8.4% of NSAID users compared to 0.6% of nonusers. There were three deaths among NSAID users secondary to perforated intestinal ulcers. In a multicenter study, 51% of long-term NSAID users were found to have signs of intestinal injury on double-balloon endoscopy. It is thought that 40 to 70% of long-term NSAID users may develop some form of enteropathy, although the incidence of diaphragm disease is only 2%. Diaphragm disease refers to characteristic short circumferential strictures resembling a diaphragm, which occur as a consequence of submucosal fibrosis. This low incidence could be due to the fact that many of the cases with diaphragm disease remain subclinical. Distinction from other enteropathies, in particular Crohn’s disease, is imperative given the implications on management.

Pathogenesis

NSAID-induced intestinal injury is thought to be multifactorial in nature with increased intestinal permeability being
the key phenomenon unlike the stomach, where inhibition of cyclo-oxygenase activity and suppression of prostaglandin synthesis plays the key role. Bjarnason et al in an effort to explain this further proposed a “three hit” hypothesis. First, the lipids of phospholipids on the mucosal surface are solubilized, causing direct damage of epithelial mitochondria. This mitochondrial damage depletes intercellular energy leading to calcium efflux and induction of free radicles. Disruption of intercellular junction occurs subsequently leading to an increase in intestinal permeability. The mucosal barrier then becomes weak causing increased infiltration of endoluminal bile acid, bacteria, proteolytic enzymes, and toxins. Neutrophils and many other inflammatory mediators are therefore activated and inflammatory damage to the lining of the GI tract, such as erosions, ulcerations, bleeding, and loss of protein occurs. Additionally, enterohepatic circulation of NSAIDs and bile augments the damage to the small bowel.\(^\text{8}\)

**Gross and Histopathological Findings**

First described by Lang et al, diaphragm disease was earlier thought to be pathognomonic of NSAIDs-related damage.\(^\text{9}\)

The study identified lesions centered on pathological accentuation of plicae circularis that resulted in fixed thin septae-like projections narrowing the ileal or mid intestinal lumen to a few millimeters. The overlying mucosal changes are often minor with superficial erosions or mild villous blunting. The thickness of the septae is dependent on the degree of submucosal fibromuscular obliteration. When minimal, these are thin and often radiologically occult. When more extensive, they can achieve a hump-like profile. The more affected segments could show short strictures with active mucosal ulceration. Serosal retraction is noted at focal short segment strictures causing compartmentalization of bowel lumen.\(^\text{10}\)

The diaphragms are thought to reflect chronic injury and attempts at repair. In a review of 10 cases, authors described multiple diaphragms ranging from 2 to 22 in number, all with stenosis of the lumen, ring-like serosal retraction, and ulceration on the diaphragm. Histopathological features confirmed focal injury with mild increase in lymphocytes and plasma cells. Unlike normal plicae, histology revealed circumscribed focus of fibrosis at the apex of the septum in the submucosa, abutting or extending into muscularis. Neutrophil infiltrate in lamina propria, cryptitis/crypt abscess, features of chronic injury such as architectural distortion, crypt short fall, ulcer associated cell lineage may occur. Neuovascular/muscular hamartoma-like change was noted in 9 out of 10 cases.\(^\text{11}\)

Neuromuscular and vascular hamartoma was originally described as fascicles of smooth muscle derived from the muscular mucosa, bundles of unmyelinated nerve fibers with scattered ganglion cells, and angiomatosus vessels, causing stenosis.\(^\text{12}\)

**Diagnosis**

Hayashi et al defined the criteria for NSAID enteropathy as:

1. History of NSAID use
2. Endoscopic findings, such as erosions, ulcers, and diaphragm-like strictures
3. Improvement in clinical manifestations and/or endoscopic findings after stopping the NSAIDs; and
4. Exclusion of other etiologies, such as inflammatory bowel disease (IBD), infection, and malignancy.\(^\text{13}\)

The sign and symptoms of NSAID-induced enteropathy are nonspecific. Indigestion, abdominal pain, constipation, diarrhea, iron deficiency anemia, and protein loss have been described. Severe life-threatening complications of bleeding, obstruction, or perforation are infrequent.\(^\text{14}\)

In a systematic review, only 55 cases with NSAID-related small bowel disease required surgery over a period of 30 years.\(^\text{15}\)

In the past, the diagnosis had been challenging and hence the clinical importance of the entity underestimated. It relied on measurement of markers of small bowel permeability and inflammation. Chromium\(^{17}\)-labeled ethylenediaminetetraacetic acid was used as a marker of permeability. This is rarely absorbed by intact small bowel; however, when the small bowel is damaged, there is absorption and subsequent excretion of the product in the urine.\(^\text{16,17}\)

**Endoscopic Studies**

Video capsule endoscopy (VCE) and balloon-assisted enteroscopy (BAE) have enabled direct visualization, localization and hence better understanding of intestinal injury. Small bowel enteroscopy (SBE) is a safe and effective technique for diagnosing small bowel diseases. SBE with prior VCE seemed to improve the diagnostic yield of small bowel diseases.\(^\text{20}\)

Macroscopic small bowel injury has been widely observed even after short-term NSAID use, however, the degree of involvement worsens with longer use.

A study utilized VCE to quantitate and assess the nature of the small bowel damage caused by NSAIDs when taken on a short-term basis. After 2 weeks of drug intake, 30 subjects (75%) had increased repeat fecal calprotectin concentrations above the upper limit of normal. VCE showed new pathology in 27 subjects (68%). The most common lesions were mucosal breaks seen in 16 subjects (40%) (● Table 1).\(^\text{21}\)

Comparing this with a prospective analysis of VCE findings of 143 patients with either rheumatoid or osteoarthritis who were on more than 1 month of NSAIDs; small intestinal lesions were identified in 44.8% of patients. Findings were classified into mild (multiple red spots or <10 erosions and/or aphthous lesions), moderate (10–20 erosions or aphthous lesions), and severe (>20 erosions or aphthous lesions, ulcers, stenosis, and/or bleeding). The lesions were mostly mild.
Other findings—

Some of the limitations of VCE showed a high (~70%) rate of small bowel abnormality in chronic NSAID users (> 3 months); 50% patients had mild and 25% of the patients.

While VCE is highly sensitive for mucosal lesions, the relevance of these findings is difficult to establish. In a study by Goldstein et al, mucosal erosions and petechiae were found in ~14% of healthy individuals. Some of the limitations of VCE include inaccurate localization of the abnormalities, rapid capsule transit which can sometimes “miss” lesions, presence of small bowel fluid or debris compounding visualization, and the lack of optimal distension.

Capsule retention is defined as lack of elimination of the camera from the digestive tract within 14 days after digestion. In a retrospective 3-year study, where radiologic workup had been negative, seven patients with NSAID enteropathy had retention of the capsule necessitating operative extraction. On average, nine diaphragms were identified in each patient by means of intraoperative palpation and enteroscopy, and confirmed at pathologic examination.

Radiological Studies

The need for complementary imaging techniques arises due to manifold reasons. Endoscopic studies undoubtedly score high in demonstration of mucosal abnormality; however, the accuracy of mural, perimural, and extraenteric manifestation is superior with cross-sectional techniques. Barium or cross-sectional studies could be used as a roadmap to exclude high-grade stricturing lesions which would preclude capsule endoscopic assessment.

Barium Meal Follow Through/Enteroclysis

Ring or diaphragm like as well as broad based strictures due to NSAID injury have been described in a long segment of jejunum. Compression spot views showed diaphragms to be thicker than adjacent folds. Broader strictures with humps were seen as producing a lifesaver-like or bagel-like configuration. The strictures are usually found close to each other in a segment of small bowel either on imaging or on subsequent laparotomy. Levi et al also described diaphragm-like strictures secondary to prolonged NSAID use in a case series of four patients.

The advantage of barium studies would be distinction of a fixed stricture from a transient abnormality due to peristalsis. Limitations include dependence on operator ability and overlap of loops obscuring some information. Patient compliance is another factor affecting use of enteroclysis techniques.

Barium studies are not advocated routinely in detection of NSAID-related intestinal injury. These, however, have been able to depict circular narrowing as pseudo folds in many cases. This sign could predict capsular retention and can be utilized as a patency tool.

CT and MR Enterography/Enteroclysis

Computed tomography (CT) and magnetic resonance imaging (MRI) are the current standard for small bowel assessment as per ECCO, the European Crohn’s and Colitis Organisation. Both require luminal distension for adequate visualization of the small bowel, as well as intravenous contrast. Luminal distension can be achieved through orally administered contrast (enterography) or through a nasojejunal tube (enteroclysis). Diagnostic accuracy in CT and MRI enterography is generally the same, with slightly higher specificity for enteroclysis. Enteroclysis is preferred due to ease of administration, better patient tolerance, and lesser radiation dose in case of CT. Jejunal distension may not be adequate and enteroclysis may provide additional benefit in case of strong suspicion of jejunal involvement.

A high degree of suspicion is required as the thin diaphragms could be radiologically occult as in these cases, the outer contour of bowel could be maintained. Multiple, short-segment strictures are the hallmarks of imaging diagnosis. Strictures may have minimal hyperenhancement or wall thickening, but these findings are typically symmetric and circumferential with respect to the bowel lumen.

A diaphragm-like stricture was found to be the most common finding in a retrospective analysis by Flicek et al, highlighting that the detection may be limited to the more advanced cases. These strictures were noted involving ileum more than the jejunum. Typically, these were multiple, circumferential, ring-like, short segment (5–10 mm length). Mild segmental mural thickening (e.g., 5–8 mm) and variable mucosal hyperenhancement were noted. The latter when present suggested active inflammation and aided in detection of strictures. Small bowel dilatation was not significant and present in less than half with maximum luminal diameter being 3.8 cm (Figs. 1A, B and 2A, B).

In a review of 11 patients with drug-induced small bowel damage (8 NSAIDs and 3 aspirin), abnormal findings in the small bowel were detected by CTE (CT enterography) in 8/11 patients (73%). Multiple lesions were found in 5/8 patients (63%). In addition, multiple lesions were shown in short-term users (6 months or shorter). The authors classified the findings and their endoscopic correlation in three subsets as depicted in Table 2.

The circumferential nature of abnormality and often the lack of significant proximal dilatation necessitate the
careful orthogonal inspection of bowel and imaging in multiple phases to confirm the presence of stricture. An elaborate discussion on optimal MRE (MR enterography) technique for small bowel imaging is beyond the scope of current review. Reduction in peristalsis/motion artefacts by administration of antiperistaltic agents and using faster acquisition techniques such as half-Fourier rapid acquisition with relaxation enhancement or single shot fast spin-echo which allow each image to be obtained in less than 1 second is of paramount importance in small bowel imaging. Balanced gradient echo sequences are useful in providing mural and extramural information. Dynamic contrast-enhanced fat saturated T1-weighted sequences aid in detection of mural inflammation, small bowel and mesenteric vasculature, and in excluding malignant causes of small bowel obstruction.\(^\text{38}\)

The literature on MRE assessment of diaphragm disease is limited. Frye et al highlighted the advantage of different pulse sequences employed in MRE and enteroclysis offering multiple time points over which a stricture can be visualized, increasing radiologist confidence. Contrast-enhanced sequences are helpful as the diaphragms enhance differently from adjacent small bowel folds (\(\text{►Figs. 3A, B and 4}\). There is an added advantage of lack of ionizing radiation when imaging younger patients.

Extramural findings are not a feature of diaphragm disease. A single case report described small bowel diaphragm disease mimicking a malignancy such as lymphoma due to multiple ileal strictures and florid mesenteric lymphadenopathy. Histopathology showed evidence of diaphragm disease and reactive nodes.\(^\text{39}\) Two of eight patients studied by Kishi et al showed mesenteric stranding accompanying mural thickening.\(^\text{37}\)

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**Table 2 Classification of CTE findings in NSAID enteropathy by Kishi et al\(^\text{37}\)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
<th>Findings</th>
<th>Incidence</th>
<th>Endoscopic correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mucosal</td>
<td>Strong mucosal hyperenhancement, no mural thickening</td>
<td>4/8 patients, 12/22 lesions, all short-term users</td>
<td>Small erosions, ulcers with mild edema, and redness</td>
</tr>
<tr>
<td>2</td>
<td>Homogenous hyperenhancement</td>
<td>Homogenous and strong mural enhancement</td>
<td>2/8 patients, 4/22 lesions, all long-term (more than 3 years) users</td>
<td>Large ulcers with edema and redness Perienteric mesenteric stranding and reactive mesenteric nodes noted</td>
</tr>
<tr>
<td>3</td>
<td>Stratified enhancement</td>
<td>Stratified or target appearance with marked wall thickening</td>
<td>4/8 patients, 6/22 lesions, both short- and long-term users</td>
<td>These patients had luminal strictures, and the lesions corresponded to annular or large ulcers associated with strictures observed on endoscopic examination</td>
</tr>
</tbody>
</table>

Abbreviations: CTE, computed tomography enterography; NSAID, nonsteroidal anti-inflammatory drug.

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Fig. 1  (A) A 60-year-old man presenting with intermittent abdominal pain of a few months’ duration. Computed tomography (CT) portal venous phase coronal reconstruction showing a symmetric short segment diaphragm like stricture (arrow) in a distal ileal loop. (B) A 33-year-old male under investigation for suspected protein losing enteropathy. Known background of nonsteroidal anti-inflammatory drug abuse due to previous (motor vehicle) accident and chronic backache. CT portal venous phase axial image showing a short segment symmetric stricture in distal ileum (arrow). Retained capsule also noted in an adjacent segment (short arrow). Ascites and mild abdominal wall edema reflecting hypoproteinemimia.
**Differential Diagnosis**

Once thought pathognomonic, diaphragm disease is not exclusive to NSAID-induced enteropathy. Diaphragm-like strictures have been described in patients with no documented NSAID use. In a study by Wang et al, five patients with diaphragm-like strictures were described all localized in the mid-to-distal ileum with no extramural or mesenteric findings. Unlike NSAID enteropathy, these were isolated findings with no evidence of erosions, ulceration, inflammation elsewhere in the bowel. Apart from one case where two strictures were identified, all other cases showed a solitary stricture, again contrasting with NSAID-related diaphragm disease where multiplicity is a common feature. Congenital diaphragm-like strictures or webs presenting in adulthood are a well-known entity. Cytomegalovirus infection and eosinophilic enteritis have been described to have diaphragm-like strictures. Multifocal stenosing ulcerations are known in Crohn’s, vasculitis, radiation enteritis, and cryptogenic multifocal ulcerous stenosing enteritis (CMUSE) among other conditions. CMUSE is defined as unexplained small intestinal multiple strictures and ulcerations of unknown origin and is thought to be an atypical form of vasculitis. It is seen in middle-aged patients with no evidence of systemic inflammation. Symptoms can show improvement with steroids and can lead to dependence. It can relapse chronically or after surgery.

**NSAID versus Crohn’s Disease**

The distinction from adult onset small bowel structuring phenotype of Crohn’s enteropathy is of prime consideration. Crohn’s disease is an idiopathic inflammatory disorder of unknown etiology with genetic, immunologic, and environmental influences, characterized by a chronic progressive destructive course in the small or large bowel. There are truly no pathognomonic features. Diagnosis of Crohn’s disease is based on a combination of clinical presentation and endoscopic, radiologic, histologic, and pathologic findings.
Proximal dilatation > 3 cm could be present in SBE or NSAIDs injury. Because of the absence of any radiological changes, MRE should be used preferentially in young patients (<35 years) and in patients in whom it is likely that serial exams will need to be performed.

The findings of Crohn’s disease on CTE/MRE can be categorized into four broad subsets: inflammation, fistula, abscess, and stenosis. Penetrating disease with fistulization or abscess formation is a consequence of transmural inflammation and deep ulceration, whereas in NSAID enteropathy, ulceration is often superficial and the serosa intact.

Evidence of active inflammation is in the form of mural thickening (>3 mm, severe if >6 mm), hyperenhancement, ulceration/cobblestone appearance, increased mesenteric vascularity (comb’s sign), regional lymphadenopathy (mesenteric lymph nodes >10 mm), and creeping fat (fibrofatty mesenteric proliferation adjacent to a chronically inflamed bowel that persists in quiescent phase). The mesentery is usually normal or shows minimal inflammation in NSAID enteropathy. Multifocal symmetric mural thickening and mild hyperenhancement are noted often of a lesser degree than with Crohn’s disease.

Stenosing disease could be secondary to active inflammation with edema and spasmodic contraction or secondary to transmural fibrosis. The latter is not associated with T2 hyperintense submucosal edema or features of mesenteric inflammation in contrast to the short segment or web-like symmetric strictures of NSAID injury. Long-segment (2–3 cm to 30 cm) involvement with terminal ileal predominance, skip lesions, asymmetric nature with preferred mesenteric border thickening, pseudosacculation of the antimesenteric border, abundant adjacent fibrofatty mesenteric proliferation with separation of bowel loops is typical of Crohn’s strictures.

Proximal dilatation > 3 cm could be present in functional Crohn’s strictures. Proximal dilatation > 3 cm could be present in Crohn’s disease, other than the typical longitudinal ulceration at the mesenteric border, there were findings of cobblestoning, fistulae (usually proximal to stricture), and pseudodiverticulae; none of which have been described in NSAID injury. In addition, adenocarcinoma or lymphoma may complicate Crohn’s disease.

Small bowel imaging should be performed as part of initial evaluation for Crohn’s disease. CTE has a sensitivity of 90% for the detection of small bowel disease in patients with Crohn’s disease and is comparable to magnetic resonance enterography (MRE). Because of the absence of any radiation exposure, MRE should be used preferentially in young patients (<35 years) and in patients in whom it is likely that serial exams will need to be performed.

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BAE can enable dilatation of strictures, although it has to be used judiciously and with caution.\textsuperscript{61} Laparotomy and small bowel resection for obstruction secondary to small bowel diaphragms may be required.\textsuperscript{26}

**Conclusion**

NSAID-related small bowel injury is common especially among chronic users. Endoscopic techniques are highly sensitive in demonstrating NSAID-related mucosal injury. The relevance of subtle findings detected is debatable. Cross-sectional techniques can aid in providing a roadmap for enteroscopy and subsequent management by highlighting diaphragm–like strictures when present and excluding extramural involvement or alternative etiologies when present. CTE and MRE have shown similar sensitivity in small bowel assessment. More data is available on CTE findings of NSAID strictures possibly reflecting its availability, lower cost, and superior spatial resolution in the detection of short

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**Fig. 5** Computed tomography abdomen and pelvis portal venous phase coronal reconstruction showing active Crohn’s ileitis with mural thickening and hyperenhancement of a long distal ileal segment (thin arrow) associated with mesenteric stranding, hypervascularity (thick arrow), and adenopathy.

**Fig. 6** Computed tomography enterography coronal post-contrast image in a patient with known background of Crohn’s showing asymmetric involvement of a long ileal segment with straightening of mesenteric border and antimesenteric sacculations (small arrow). Prominent mesenteric vascularity (comb’s sign) is also noted (big arrow).

**Fig. 7** (A) Magnetic resonance enterography T2 Haste coronal image in a patient with Crohn’s ileitis showing a long segment structuring disease (big arrow) with evidence of penetration at the mesenteric border (small arrow). (B) Coronal T1 FS post-contrast image in a patient with Crohn’s ileitis showing penetrating disease in form of interloop adhesions and entero-enteric communication (arrow).
segment strictures. Short segment, symmetric, multifocal diaphragm-like strictures with mild mural thickening and variable hyper enhancement are typical of NSAID enteropathy in contrast to long segment, asymmetric longitudinal ulcers on the mesenteric border in Crohn's disease. Penetrating disease is absent and mesenteric findings are uncommon or mild if present in NSAID-related disease.

Conflict of Interest
None declared.

References