In cases of acute abdominal pain, multi-detector computed tomography (MDCT) is used more and more frequently. The recent appearance of MDCT poses the problem of the diagnostic performance in detecting hollow organ perforation and in the search for the site and cause of perforation. In 15 consecutive patients whose diagnosis of perforated gastroduodenal ulcer was certain, we studied the performance of MDCT in the positive diagnosis and etiology of gastroduodenal perforation.

**Material and methods**

Over an 18-month period (from October 2003 to March 2005), 19,251 CTs were done. Of these 19,251 examinations, 653 were done in a context of acute abdominal pain. Fifteen of these were identified as having an ulcer perforation in the hospital’s information system (HIS). Patient age ranged from 24 to 90 years (mean, 56 years). There were seven women and eight men. During the same period, five patients also had an ulcer perforation, but were not examined with the MDCT. In this period, a total of 20 patients were hospitalized for a gastroduodenal ulcer perforation. In all the patients studied, the diagnosis of ulcer perforation was confirmed either because the patients underwent surgery or because progression after treatment using the Taylor method was favorable, with later confirmation of a scar on upper endoscopy. Of the 15 patients examined with CT, the a priori diagnostic probability established by the clinician based on the clinical and biological data, as well as the plain abdomen x-ray when available, were included.
on the clinical chart of the emergency department.

The CT was done to confirm a clinical impression (5/15), either because of atypical clinical signs — peritonitis with no clear etiology (8/15) — or abdominal pain associated with a hypovolemic shock (2/15).

The protocol used, with a 16-row multidetector CT, included a helical acquisition at 70 s with immediate injection of 2 mL/kg of contrast agent at 300 mosmol/L, a 1-mm collimation, and reconstruction in 5-mm and 1-mm contiguous slices. The analysis was immediate on a worksession, allowing multiplanar reconstructions that were used systematically.

In all 15 patients, we looked for wall discontinuity (direct sign) and indirect signs such as pneumoperitoneum, bowel wall thickening, peritoneal fluid, and abdominal fat blurring.

Pneumoperitoneum was classified into two groups: large or composed of a few small gas bubbles (small).

We also analyzed the location of the indirect signs in hopes of discerning the etiology.

The information retained was that present in the practicing radiologist’s report. There was no attempt to reexamine the images or to modify the analyses retrospectively.

When a plain abdomen x-ray was taken (n=9), it was compared with the CT to detect pneumoperitoneum, by relating it to the abundance of pneumoperitoneum described on the CT.

In eight patients (53%), stomach or duodenal wall abnormalities were found, which were either bowel wall thickening greater than 3 mm or intraparietal gas bubbles (fig. 3). Abnormalities of abdominal fat (local fat blurring) were present in 11 cases (73%). In ten cases (67%), we found peritoneal fluid (fig. 4). Discontinuity of the wall was visualized in eight patients (53%). In two out of eight cases, the wall discontinuity was not visible on the axial slices, but was present on the multiplanar reconstructions. In the other cases, it could not be demonstrated on CT (fig. 5-7).

**Discussion**

Ulcers are frequent, affecting 10% of the Western population. The incidence of duodenal ulcer is 80,000 new cases per year in France. The prevalence of the duodenal ulcer is 8% and the gastric ulcer 2%. (1) Mortality is 1% for duodenal ulcer and 2.5% for gastric ulcer. This is a chronic disease that evolves by episodes, interspersed with more or less long periods of remission. Two entities should be distinguished depending on location. The duodenal ulcer, always benign, is responsible for 80% of cases, whereas gastric involvement, which can become cancerous or occur on a preexisting cancer, affects 20% of patients. The main causes are, by order of frequency, *Helicobacter pylori* infections, nonsteroidal anti-inflammatory drugs, and smoking. The typical symptoms are epigastric pain like hunger or a painful cramp with no irradiation, punctuated by meals (with a pain-free interval lasting 1-3 h). It is asymptomatic in approximately one case out of five, revealed by an endoscopic examination for another disease or during a complication. The most frequent center for the duodenal ulcer is the bulb, whereas for the stomach it is the antrum. The main complications are digestive tract hemorrhage (from minimal to catastrophic), perforation, ulcerous stenosis, and degeneration in cases of gastric location (by re-epithelialization of the ulcer crater) (2, 3).

Ulcer perforations have a frequency estimated at 1%. Abdominal spasms is the main sign, particularly if it occurs after violent, stabbing epigastric pain that comes on suddenly. The perforation of a hollow organ in the free peritoneum results in extravasation of air outside the digestive tract. A plain abdominal x-ray is taken looking for pneumoperitoneum.

Therapy can be surgical or conservative depending on the subject’s condition, the diagnostic certainty, and the time delay since the onset of symptoms. In a young subject who is in good general health, whose diagnosis of ulcer perforation is certain, and the delay to diagnosis short, the Taylor method (digestive aspiration, antibiotics, antiulcer drugs) can be attempted. In other cases, surgery is necessary to clean the peritoneum and to plug the opening, or to resect the ulcerous zone. In a certain number of cases, imaging helps choose the best strategy. Associating typical symptoms and pneumoperitoneum on the plain films provides a diagnosis of perforated ulcer. Management by a surgical team is mandatory at this stage, and an abdominopelvic CT scan is therefore not indispensable.

On the other hand, the multidetector abdominopelvic CT has its place in two other distinctive contexts: clinical suspicion is high but there is no pneumoperitoneum on the plain abdominal radiograph; the clinical signs are atypical, for example in cases associating abdominal pain and hypovolemic shock, the clinical results are unclear, or, on the contrary, peritonitis is present with no etiological explanation.

In the first case, the search for pneumoperitoneum, not seen on the plain abdomen x-ray, is indispensable. The CT has proved its superiority in terms of sensitivity and specificity compared to the plain abdomen film for the diagnosis of pneumoperitoneum (4, 5). One study found a 69% pneumoperitoneum detection rate for the CT, all types of hollow organ perforations taken together, whereas pneumoperitoneum was found in only 19% of the cases on plain abdomen images (6, 7). Another study found 92% pneumoperitoneum cases on CT versus 74% on plain abdomen images (8).

In our study, the CT demonstrated pneumoperitoneum in all the cases, while it had been seen in only three out of nine plain abdomen images. Closer analysis of these results shows that small pneumoperitoneum on CT (six cases) is rarely visible on plain abdomen x-rays (zero cases), whereas large pneumoperitoneum on CT (nine cases) was more frequently visualized on the plain abdomen images (three cases).
A recent study showed that localizing the pneumoperitoneum in case of perforation of a hollow organ can point toward the digestive tube region that is perforated. The authors of this article explain that the sign of the falciform ligament (accentuation of the falciform ligament’s visibility, which is molded by extradigestive air) is more frequent with proximal digestive perforation than in distal perforation, without this being a formal sign for the cause of the perforation (9).

Table I

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<th>Large pneumoperitoneum</th>
<th>Small pneumoperitoneum</th>
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<tr>
<td>Plain abdomen films</td>
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<td>MDCT</td>
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An exclusively supramesocolic location of the pneumoperitoneum is systematically found when there is gastroduodenal perforation in reports by other authors, whereas there is generally no pneumoperitoneum in cases of perforated appendicitis; the location of pneumoperitoneum in cases of perforated sigmoiditis is more random (supra- and submesocolic) (10). The CT also targeted indirect signs of perforation other than pneumoperitoneum, such as peritoneal fluid, abdominal fat blurring, and bowel wall thickening. These indirect signs are additional arguments for the diagnosis of perforated ulcer, even if they are neither sensitive nor specific (11-14). They also aid in the etiological diagnosis; location of all these signs guides toward the area of digestive perforation.

In one study reported in the literature, in 40 patients with perforation of a hollow organ (all sites together), a 92.5% rate of peritoneal fluid was found (10). All patients (9/40) with gastric or duodenal perforation had peritoneal fluid associated with pneumoperitoneum with a supramesocolic location. The authors considered the supramesocolic location of the peritoneal fluid a persuasive argument for the diagnosis of ulcer perforation.
In this same study, the presence of pneumoperitoneum was only found in 60% of cases, which can be explained by the fact that the authors studied all types of digestive perforation, including appendicular perforations, which did not systematically give with pneumoperitoneum.

A retrospective study on 14 patients with a surgically proven ulcer perforation found results close to those in our study (15). Indeed, the authors found 100% rate of pneumoperitoneum, 71% peritoneal fluid, and 36% anomalies of abdominal fat. The breach in the wall was found in 36% of the cases (5/14 patients). The authors concluded that the advantage of CT in the possibility of diagnosing pneumoperitoneum in 100% of cases, but observed a low rate of detection of the wall breach using conventional CT. It should be specified that the CT used in this study was a conventional CT, with 5-mm slices. The multidetector CT compared to the conventional CT also seems to have advantages in the search for the wall breach when there is colon perforation (16).

Bowel wall thickening and blurring of abdominal fat around the region are two signs that may point to a gastroduodenal perforation, depending on their location. Nevertheless, their incidence seems to be higher in cases of distal intestinal perforation (appendix, colon, rectum) than in cases of proximal perforation (9).

In an Italian study investigating 146 consecutive patients with a gastroduodenal perforation, pneumoperitoneum was found in only 12 cases. In these patients, peritoneal fluid was the only indirect sign of perforation in 66% of them (17).

The appearance of multidetector CT provided helicoidal acquisitions as well as reformattting in all the spatial planes. Of the eight patients in whom the wall breach was evidenced, the axial slices alone demonstrated the opening only six times. However, in two patients (25%), the wall opening was detected only on multiplanar reconstructions, whereas it was not visible on the axial views. This illustrates the contribution of the multiplanar reconstructions provided by multidetector CT, which can refine the diagnosis in certain difficult cases.

The focus of the perforation was not determined in nearly half the cases studied (7/15), even if its origin was strongly suspected based on indirect signs of perforation, despite the multiplanar reconstructions and the 1-mm thin slices. Several expla-
nations can be offered. The examination took place in an emergency situation, often interpreted by a junior radiologist only. The absence of an archiving system did not allow senior radiologists to read all the examinations. A retrospective analysis by expert radiologists would perhaps have improved the detection of the wall breach.

**Conclusion**

It seems that the multidetector CT is useful in diagnosing gastroduodenal ulcer perforation when the clinical examination combined with the plain abdominal films does not provide a clear diagnosis, whether this be the result of not detecting pneumoperitoneum on plain films or of atypical clinical signs. It can detect pneumoperitoneum that has not been seen on plan abdominal x-ray and point toward the perforation site because of the wall abnormalities and the peritoneal fluid. It also provides, in real time in 53% of cases in our experience, to directly visualize the breach in the wall, localizing the ulcer perforation site. Using three-dimensional reformatting is indispensable to improving the detection of the wall breach if it has not been visualized on the axial slices.

**References**