Ultrasound Obtains Pole Position for Clinical Imaging in Acute Diverticulitis

On the background of the German Guideline Diverticular Disease / Diverticulitis.

Key words
- Diverticulitis
- diverticular disease
- intestinal ultrasonography
- ultrasound

This paper reviews and interprets the role of ultrasonography in view of the recently published Guideline on diverticular disease of the Consensus conference of the German Societies of Gastroenterology (DGVS) and Visceral Surgery (DGAV) implying a new classification of diverticular disease (CDD). Qualified US is not only equipotent to qualified CT and frequently effectual for diagnosis but considers relevant legislation for radiation protection. Unsurpassed resolution allows detailed resolution thereby allowing to differentiate and stratify the relevant types of diverticular disease. Subsequently, US is considered the first choice of imaging in diverticular disease. Vice versa, CT has definite indications in unclear / discrepant situations – or insufficient US-performance.

The 2014 Consensus conference of the German Societies of Gastroenterology (DGVS) and Visceral Surgery (DGAV) on diverticular disease has passed a new classification of diverticulitis and the different facettes of diverticular disease (CDD). This classification addresses and stratifies different types of diverticulitis but also comprises asymptomatic diverticulosis, symptomatic diverticulitis without peridiverticulitic phlegmon, and diverticular bleeding (Table 1) [1].

Table 1: Classification of diverticular disease (CDD)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>asymptomatic diverticulosis</td>
</tr>
<tr>
<td>1</td>
<td>acute uncomplicated diverticulitis</td>
</tr>
<tr>
<td>1a</td>
<td>diverticulitis/diverticular disease without peridiverticulitic phlegmon</td>
</tr>
<tr>
<td>1b</td>
<td>diverticulitis with phlegmonous peridiverticulitis</td>
</tr>
<tr>
<td>2</td>
<td>acute complicated diverticulitis</td>
</tr>
<tr>
<td>2a</td>
<td>microabscess</td>
</tr>
<tr>
<td>2b</td>
<td>macroabscess</td>
</tr>
<tr>
<td>2c</td>
<td>free perforation</td>
</tr>
<tr>
<td>2c1</td>
<td>purulent peritonitis</td>
</tr>
<tr>
<td>2c2</td>
<td>fecal peritonitis</td>
</tr>
<tr>
<td>3</td>
<td>chronic diverticular disease</td>
</tr>
<tr>
<td>3a</td>
<td>symptomatic uncomplicated diverticular disease (SUDD)</td>
</tr>
<tr>
<td>3b</td>
<td>relapsing diverticulitis without complications</td>
</tr>
<tr>
<td>3c</td>
<td>relapsing diverticulitis with complications</td>
</tr>
<tr>
<td>4</td>
<td>diverticular bleeding</td>
</tr>
</tbody>
</table>

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Anatomy

Colonic diverticula are acquired outpouchings of the mucosal and submucosal layers penetrating a muscular hiatus of the colonic wall next to mucosa supplying arteries. Muscular hypertrophy with elastosis is the morphological hallmark and prerequisite for the development of sigmoid (pseudo)diverticula [20-23]. Thus muscular hypertrophy is almost always visible by US (Fig. 1).

Macropathology and pathogenesis

As an inflammatory process diverticulitis usually starts within the diverticulum (sequel to occlusion by a koprolith) or at the neck of the diverticulum (ischemia or mechanical injury) (Fig. 2). Accordingly, initially only one diverticulum is concerned. Inflammation leads to increased pressure followed by microperforation evoking a peridiverticular mesenteric inflammatory reaction which may progress to a pericolic and mural phlegmonous infiltration which secondarily may involve further diverticula and/or cause fistulisation, sealed perforation, abscess, free perforation, peritonitis, or a stenosing inflammation of such small gas bubbles inside vs outside a diverticulum can easily be misleading whereas gas covering an abscess is more likely masked at US (but rare in small abscesses (Fig. 3a) and technically avoidable in larger ones (Fig. 3b)).

Fig. 1 Muscular hypertrophy as a prerequisite for diverticulosis (left colon) is well visible at US. Impressive hypertrophy / elastosis of the muscular layer in diverticulosis (type 0).

Fig. 2 Occluding koprolith which has not passed the diverticular neck. As a consequence, inflammatory suppuration (*) has concentrated in the diverticulum and perforation appears on the brink. As far as shown here, this is considered CDD type 1b because of the echopenor sealing (arrow); in fact perforation was visible in other sections.

Fig. 3 Contrast enhanced ultrasound (CEUS) clarifies that the fibrofatty mass / ‘mesenteric cap’ comprises a hyperperfused peridiverticular mesenteric inflammatory reaction. Acute diverticulitis CDD type 1a (transverse section through the inflamed diverticulum). Enhancement of Sonovue®-bubbles 1.33 min p.i.

Almost 30% of diverticulitis cases are complicated. The US-pathology of sigmoid diverticulitis (SCAD) refers to an unspecific morphology is of particular importance against the background of impressive cyclic variations of hospital admissions for acute diverticulitis with highest frequencies during the summer months [25]. Because SCAD leads to segmental broadening of the affected colonic wall and may also cause a mesenteric reaction, this seasonal periodicity but also the new tendency towards a non antibiotic treatment of uncomplicated diverticulitis [26, 27] (possibly misdiagnosed and representing only minor summer infections) may be regarded important issues for a differential diagnosis of SCAD vs. ‘true’ acute diverticulitis.

Smoldering diverticulitis is a surgically coined phrase for patients with sustained symptomatic diverticulitis, in whom diverticulitis remained obscure at CT, sometimes also barium enema and/or colonoscopy until sigmoidal resection was performed (histological diagnosis) [28]. The
role of US in this condition is entirely unexplored.

**Ultrasonography**

The core finding of diverticulitis at US is (i) “THE diverticulum with different echogenicity in the centre of a pericolonic fatty tissue reaction (Hollerweger [7])”, i.e. a diverticulum with a prominent hypochogetic mucosa (± fluid collection, ± echogenic koproolith) surrounded by an echogenic mesenteric cap (Fig. 3, 4, 6) in conjunction with (ii) a hypochogetic initially asymmetrical wall thickening (>4-5 mm) with loss of wall layering, reduced wall compliance under pressure and narrowing of the lumen, and (iii) occasionally hypochogetic ‘inflammation lanes’ which are considered inflammatory exsudation. Abscess, microperforation and fistulas are characterized by gas echos on top of a fluid collection in the mesentery (at US easier recognized if closer to the diverticulum) or within a hypochogetic lane. Free peritoneal or retroperitoneal gas proves free or retroperitoneal perforation. Hypertrophy / elastosis of the hypochogetic external circular muscle layer is an obligatory sign in diverticular disease and leads to uprightening of the arterioles allowing outpouching of the diverticula parallel to the arterioles under increased pressure. This pattern is well visible at US (Fig. 4b, 7).

As diverticulitis starts in a single diverticulum only, this is usually the site of maximum pain under compression (and the classical point of interest to put the transducer on), but inflammation can secondarily spread in longitudinal direction. Beginning in the outpouched mucosa inflammation of the diverticulum is invisible at colonoscopy unless inflammation spreads back from peridiverticulitis to the mucosa or unless a tear in the diverticular neck due to the passage of a koproolith has triggered diverticulitis [29]. Hence, the desired information from cross sectional imaging is not only whether abscess or perforation are present, but also whether the a.m. morphological criteria of diverticulitis are present, or segmental colonic inflammation involves ‘innocent’ diverticula only.

Uncomplicated and complicated diverticulitis are distinguished variants in a spectrum of different severity, rarely an escalating process, and perforated diverticular disease, if present, usually occurs as the first manifestation and not as a complication of prior episodes as claimed in Parks’ understanding [30-32]. However, acute diverticulitis may progress overnight (Fig. 4b, 6). By nature, inflammation is a dynamic process, and a qualified visualization would require reiterative examinations. This – to a certain extent – precludes CT from being a method of choice.

**Quality considerations**

Frequently the objection is raised that ultrasonography depends on the equipment...
and on the examiner. This is pretended against the background that some physicians, but mainly surgeons, tend to refrain from accepting clinical evidence and statements reported from the US suite. If used as an excuse, however, this won’t hold water [33].

However, some problems should not be overseen: as “routine” US still is frequently performed on a low level standard in Germany (overcome equipment, little experience) consequent continuous quality control covering the real needs should be applied with respect to (i) equipment, (ii) individual qualification, and (iii) pictorial quality.

### Equipment

Modern US devices usually provide all technical prerequisites for diagnosing acute diverticulitis. A curved probe with ~3.5–6 MHz is the transducer of choice for the first approach (overview, point of maximum pain) and frequently effective for diagnosis. However, a linear probe with ~5–12 MHz is required to reach the state-of-art diagnostic standard and allows detailed resolution of the wall layers and identification of the classification criteria.

### Examiner

No medical technique ever can be valid if the examiner is not familiar with it. This holds true for US, as it does for the CT. Irrespective of variable individual talents literature lets us assume adequate training in US for diverticulitis giving valid results (only) after ~500 (targeted) US-examinations [34, 35]. Similarly, a basic course followed by 3 months (supervised) practical training in the US suite has also shown adequate reliability in diagnosing acute diverticulitis [36]. Practically, among all frequent diseases of the intestines (appendicitis, IBD, infections, ischemia), diverticulitis will be the easiest one to be safely recognized by a trainee. Equally important to US expertise, profound knowledge of the respective differential diagnoses including their pathogenesis, pathology, and course is mandatory. In summary the concept to which in Middle-Europe the term “Clinical Ultrasound” refers.

### Ultrasonography on the background of the CDD

#### Principles and practice

Obviously it becomes clear to everybody from the radiation exposure (increasingly important with the decreasing age of the affected patients) that not every patient with suspected diverticulitis can and should undergo CT, and it has also become evident, that not every patient with minor perforation/abscess must be operated. As a consequence, however, without CT-scan or operation, no classification of diverticulitis for the vast majority of patients exists, because the hitherto used classifications (Hinchey, Hansen-Stock) were based on either operative or CT-criteria.

On the other hand, merely ‘clinical diagnosis’ of diverticulitis is insufficient (sensitivity ~65%) and potentially misleading [4, 37–40]. Also apostrophized as “left sided appendicitis”, the triad (i) spontaneous pain in the left lower quadrant, exaggerated by movements, (ii) an inflammatory reaction (CRP, WBC, temperature) and (iii) local guarding upon palpation, is important with the decreasing age of the affected patients (e.g. outpatients and emergency cases), (iii) because it is cheap, and, (iv) because apart from a reliable initial diagnosis – it allows a close follow up, and – last not least – (v) because it has higher resolution power than the CT-scan.

US is applied directly at the point of pain and guarding which usually guides to the inflamed diverticulum and/or its complication [42]. The inflamed diverticulum may (Fig. 2) or may not contain a hyperechoic more or less crescent-shaped koprocolith (Fig. 3) [6], but once extruded, spontaneous drainage of pus into the colon is hypothesized to decrease pressure and the risk for perforation [43]. This is an interesting observation which deserves further subtle research.

In the case of conflicting results (e.g. disparate to the clinical impression) CT is regarded a valuable complementary method. Occasionally, abscesses deep in the pelvis or distant mesenteric abscesses originating from the lower sigmoid are responsible for such discrepancies. CT is considered decisive here, but vaginal or rectal US with endfire transducers may be a valuable US alternative, which is probably underused in Germany.

The current status shows that US meets almost all requirements for an exact diagnosis of acute diverticulitis. Equally important: reiterative examinations enable the physician to precisely follow the disease course and to detect complications as early as possible. Two points deserve further attention: the need for research as mentioned above, and the need for training which will be addressed in a pictorial essay.

### References:

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