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Hydrocolonic sonography in the detection of large bowel disease

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Background. *The presence of fluid in the bowel lumen improves the sonographic visualisation of the gastrointestinal tract, thus permitting earlier and more accurate detection of pathological changes. Hydrocolonic sonography (HS) is a method of examining the colon after it has been cleaned and filled with water.*
Patients and methods. *We have evaluated the method in a group of 56 patients by comparing its results with the findings of colonoscopy, double-contrast barium enema or surgery.*
Results. *HS had an overall accuracy of 86 %, a sensitivity of 81 %, a specificity of 92 %, a positive predictive value of 91 % and a negative predictive value of 82 %.*
Conclusions. *The technique is not suitable for examining the rectum, but apart from that it is comparable in usefulness to double-contrast barium enema. The main limitation of HS is that it requires a lot of experience and skill on the part of the sonologist, which affects its acceptability for diagnostic evaluation of the colon.*

Key words: colonic diseaes-ultrasonography; colonic neoplasms-ultrasonography; hydrocolonic ultrasonography; polyps

Introduction

Ultrasonic examination of the abdomen is a widely used diagnostic method, which usually represents the first step in the evaluation of various abdominal symptoms. In examining the bowel, we are hampered by the physical limitation of the technique, based on the fact that the difference in acoustic impedance between solid tissue and gas is so great that almost the entire emitted ultrasound wave returns to the transducer, producing an artefact instead of a useful image. Therefore, the examination of the gastrointestinal tract seemed impossible at first. However, a solution was suggested already in the seventies by Lutz and Rettenmaier with the description of the »pathological cocarde«; they noticed that a much better visualisation of the gastrointestinal tract was obtained if pathological changes were present in its wall.[1,2] The criteria of a pathologically altered bowel wall are: thickening, loss of compressibility, changes in luminal width and peristaltic activity, absence of

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colonic haustration, altered blood supply and changes in surrounding tissues related to the diseased bowel. The terms used in the literature for a pathological alteration of the bowel wall are a pathological target when seen in the transverse view and a pseudokidney when seen in the longitudinal view. However, imaging of a pathologically altered bowel wall also has its limitations. It is possible only in advanced disease and not at the stage of minor incipient changes. Moreover, intraluminal masses are not displayed, and the posterior wall is not clearly visible. Finally, a pathological target is not a specific sign and it can be false positive. A further step towards ultrasonographic assessment of the gastrointestinal tract was made in the late seventies by Fleischer who noted that the image was significantly improved if at least 90 % of the bowel lumen was filled with fluid; this allowed him to distinguish between the small and the large intestine as well as between the intestine and other abdominal structures.[3] A more detailed visualisation of the gastrointestinall tract was not possible because of the inadequate resolution of the compound scanners used at the time. In the mid-eighties, after the appearance of high resolution scanners providing real-time images, this idea was revived, developed further and tested clinically by Limberg who named his method of examining the colon hydrocolonic sonography.[4] We have tested the method in a group of 56 patients and now report the results of our evaluation.

Patients and methods

Patients

A total of 56 patients (37 women and 19 men, average age 61.3 years) gave their consent for the examination. They shared a history suggestive of colonic disease. Two patients with a history of a malignant tumour of the colon treated by resection required evaluation of the anastomosis.

Methods

Hydrocolonic sonography (HS) is a method of examining the colon after it has been cleaned and filled with water to improve the visualisation. The success of HS depends to a large extent on the preparation of the colon, accomplished with a diet and use of laxatives according to different schemes. Our patients did not ingest any solid food a day before the examination. In the afternoon on the preceding day, they took a laxative (Coloclens) with a double quantity of water. Early in the morning on the day of the examination, they drank three litres of an electrolyte solution (Golytely). Directly before the examination, they received an intravenous injection of 0.5 to 1 ml of glucagon at a concentration of 1 mg/ml (GlucaGen, Hypo Kit) to relax the bowel. The colon was then filled with 1000 to 1500 ml of water at body temperature, instilled with the use of an enema delivery system (Nicholas Kolon-Diagnostic-System), usually employed for barium enemas. During the instillation of water, the patients changed position to achieve optimal filling of all segments of the colon. The filling of the colon with water was observed with a low-frequency transducer (3.75 MHz). It was terminated when the caecum and ileocaecal valve came into view. Then we started examining carefully the colon segment by segment with the low-frequency transducer to evaluate the position of the bowel loops, the width of the bowel lumen etc. If a pathological change was noted, we tried to analyse more accurately the structure of the colonic wall using a high-frequency transducer (7.5 MHz). The examination was performed on the patient lying supine and in both lateral positions. In some younger patients, the rectum and sigmoid were examined also in the upright position. For demonstrating the flexures, a lateral intercostal route was usually chosen. The duration of the examination was limited by the action of the relaxant to about 15 minutes. After emptying the water from the colon, the patients immediately under-

went colonoscopy (CS). If CS was not feasible, the sonographic findings were compared with the results of surgery or double-contrast barium enema. The patients gave a written informed consent for the examination. Afterwards they were asked to describe their tolerance for HS as compared to CS or barium enema. The ultrasonic examinations were performed with Toschiba ultrasonography units (SSA-270A and 100A), using 3.75 and 7.5 MHz transducers.

The sonographic diagnosis was based on the following criteria: a constant thickening of the colonic wall, changes in the luminal width of the colon and the sonographic structure of its wall (the quantity of echoes and presence of the normal layers), evidence of intraluminal masses fixed to the wall, loss of haustration and changes in pericolonic tissues. The HS findings were compared with the results of CS, double-contrast barium enema or surgery. With the use of statistical analysis the accuracy, sensitivity, specificity and the positive (PPV) and negative predictive value (NPV) of the method were assessed.

Results

Feasibility

In three female patients of advanced age (average 80.3 years), HS could not be performed because they were unable to retain the instilled water, and so they were excluded from the series. CS could not be carried out in eight of the 56 patients because of poor general status (two patients) or intolerance for the procedure (six patients). Three of the eight patients were the previously mentioned women who were excluded from the study. In the remaining five patients, the results of HS were in four cases compared with surgical findings and in one case with double-contrast barium enema.

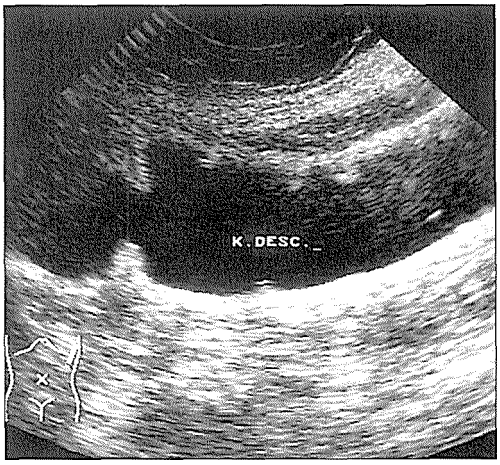

Figure 1. Normal colon descendens as displayed by hydrocolonic sonography. Five layers differing in echogenicity can be seen within the colon wall.

Normal findings

In 29 patients who all subsequently underwent CS, the HS result was interpreted as normal. HS missed six polyps (four < 7 mm in diameter in the sigmoid and two = 7 mm involving the sigmoid and rectum) in four patients, and one rectal tumour located at a depth of 10 cm. It identified correctly faecal material in patients with inadequate bowel preparation and even the remnants of an undigested pill in a patient's caecum. This

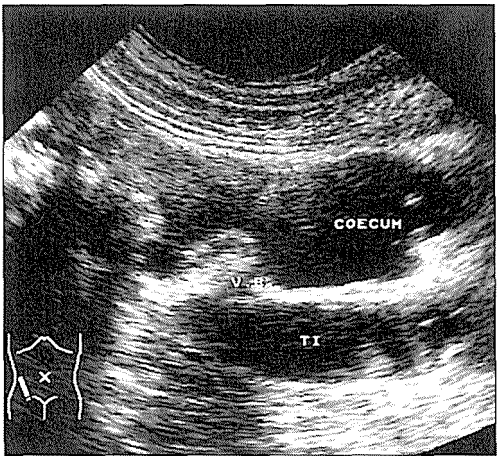

Figure 2. Normal coecum, ileocaecal valve and terminal ileum as displayed by HS.

group included the two patients with a history of colonic resection who both had a normal anastomosis.

Tumours

In 17 patients, HS demonstrated tumours, of which 65 % were located in the left colon. In four of the 17 patients, the finding was confirmed at surgery, CS having proved impossible. The remaining 13 patients underwent CS, which was complete only in three; in the other 10 patients, the bowel was displayed only to the level of the tumour stricture, impassable for the colonoscope. CS confirmed 12 of the 13 tumours and missed one involving the colon and rectum. This patient was later subjected to a double-contrast barium enema, which confirmed the result of HS. The HS findings were accurate in all 17 patients. In six of the 17 patients (35 %), the tumour was visible also on conventional abdominal sonography.

Polyps

HS detected polyps in four patients, who all subsequently underwent CS. Two polyps (one of 5 mm in diameter located in the sigmoid, and the other of 20 mm in the transverse colon) were confirmed on CS, while two (one of 7 mm in the transverse colon, and the other of 17 mm in the caecum) were not.

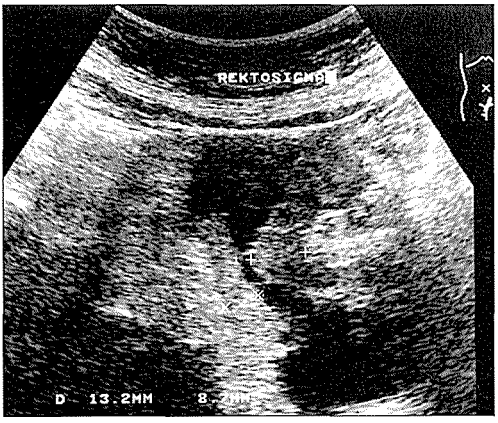

Figure 3. Colonic carcinoma (rectosigma): concentric thickening of the wall and narrowing of the lumen.

Diverticulosis

HS detected two cases of diverticulosis; one was confirmed by CS and the other by double-contrast barium enema.

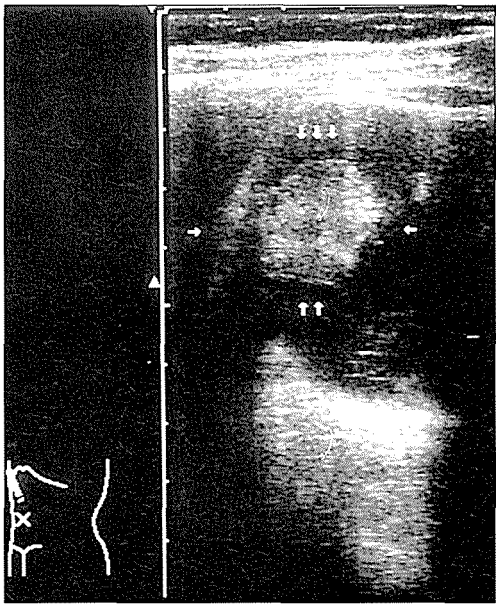

Figure 4. Colonic carcinoma (hepatic flexure): intraluminal mass.

Crohn's disease

In a patient with known Crohn's disease, HS, performed in the course of preoperative preparations, disclosed three strictures, located under the splenic flexure, at the transition from the transverse colon to the splenic flexure, and at the transition from the caecum to the terminal ileum, which were all confirmed at surgery. None was visible on CS, as this had to be terminated in the descending colon because of pain.

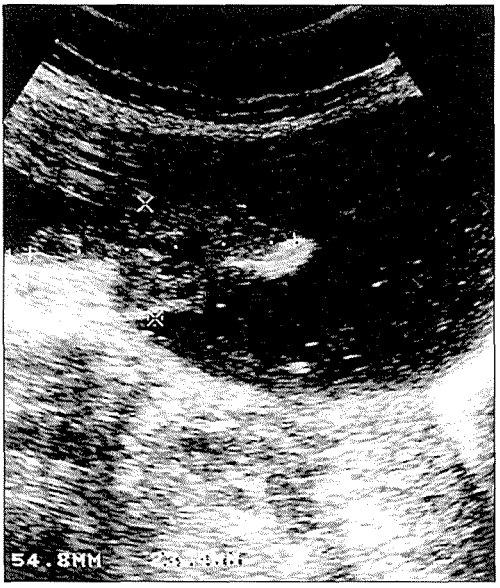

Figure 5. Colonic carcinoma (coecum): eccentric thickening of the wall. Missed on colonoscopy.

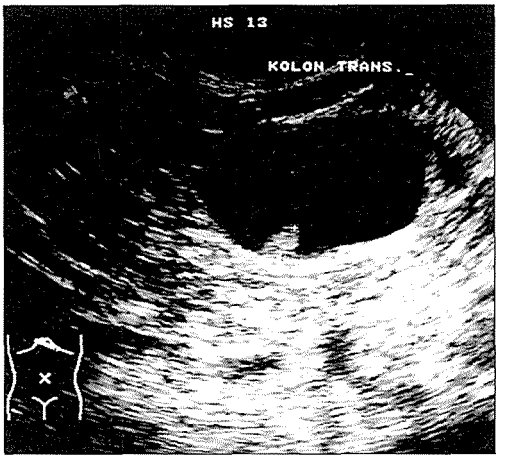

Figure 6. Small colonic polyp (7 mm); the structure of the colon wall remains intact.

Statistical results

The calculated accuracy of HS was 86 %, sensitivity 81 %, specificity 92 %, PPV 91 % and NPV 82 %.

Tolerance for HS

The examination was well tolerated. The patients experienced no pain, only some discomfort due to the retention of water. They evaluated both CS and double-contrast barium enema as painful because of the insufflation of air.

Discussion

Two basic facts vital to the understanding of ultrasonic evaluation of the gastrointestinal tract are that good visualisation is possible if the wall of the gastrointestinal tract is pathologically altered and if at least 90 % of the lumen is filled with fluid.[1-3] In the seventies, attempts to display pathological changes of the colon after it had been filled with water were limited by the technical shortcomings of the compound scanners used at the time.[5,6] When these limitations were overcome, Limberg developed hydrocolonic sonography, with which he was able to display the colon from the rectosigmoid border to the caecum in 97 % of patients.[4,7-15] Later on several authors reported that they could not demonstrate the flexures[16-18] or even the greater part of the colon with HS.[19] We had no such difficulties, provided that the instillation of water did not pose a problem. We also confirmed the experience of those authors who found it impossible to adequately visualise the rectum by HS,[8,11-4,16,19,20] as we missed a rectal tumour and a 7 mm rectal polyp. We exceptionally managed to display the rectum in young and slim patients, and we even diagnosed a rectal tumour in the form of an intraluminal mass.

The main aim of investigations of the colon is an early detection of cancer. Colonic cancer has a high incidence in the developed world. In Slovenia, the survival of these patients is below the European average, mainly on account of late detection.[21] The value of HS must be analysed by comparing this method with conventional ultrasound, double-con-

trast barium enema and CS. Of the 17 tumours correctly diagnosed by HS, six (35%) were seen also on conventional ultrasonography. This compares well with data from the literature[12,22], suggesting that HS is able to detect two thirds more tumours than conventional ultrasonography. On HS, a tumour is seen as a stenosed segment of bowel with associated concentric or eccentric incompressible thickening of the wall or as an intraluminal mass. Of special interest in our series is the case of the patient with a caecal tumour, which was missed on CS but confirmed on double-contrast barium enema and at surgery. We also managed to demonstrate a rectal tumour located at a depth of 8 cm; to our knowledge the detection of tumours in a similar location by HS has not been reported in the literature. HS thus showed a sensitivity of 100 % and a specificity of 100 % for the diagnosis of cancer of the colon excluding the rectum. Similar results have been reported by several authors.[10,11,23,24] In other studies, however, the method was less successful.[16,17,19] In comparing HS with CS, we must bear in mind that the colonoscopist does not reach the caecum in 10 % [25] to 30 % [26] or, according to some reports, even up to 45 % [10,16] of cases. Consequently, about 10 % of colonic tumours are missed on CS.[16] So, in case of disagreement between the radiological and endoscopic results, it is advisable to carry out further investigations rather than rely on the result of CS,[27] which may be inaccurate, as illustrated by the missed caecal tumour in one of our patients. Moreover, CS in our series was able to display the colon beyond a tumour stenosis in only three cases, whereas HS managed to do so in as many as 15 cases. An undisputed advantage of CS is the possibility of biopsy. Except in one case (the rectal tumour missed by CS), a comparison with double-contrast barium enema was not performed for two reasons: first, because contrast studies cannot be done after HS as the residual water would interfere with contrast coating the mucosa, and second, because most authors use CS as the gold standard. In comparing HS with double-contrast barium enema, which has been shown to have a sensitivity of 95-98 % for the detection of colorectal cancer[28], we must consider also the missed rectal tumour. If this is taken into account, the sensitivity of HS in our patients was 94.5 %. As a representative of cross-section imaging techniques, HS, in contrast to CS and barium enema, can display the bowel in cross-section with all its layers and adjacent tissues, which makes it suitable for cancer staging. In other studies, HS permitted accurate assessment of the T-stage for 86-97 % of evaluated tumours[13,16,22,23] and the N-stage for 35 % [16] to 50 % [22] of tumours. In our patients, we were mostly able to distinguishing the normal wall layers with the low frequency transducer, but we rarely managed to use the high frequency transducer because of poor depth penetration, and we were unable to assess reliably the T-stage of tumours or to display the adjacent lymph nodes.

Since most colorectal cancers develop from neoplastic polyps/adenomas, an early detection of these lesions constitutes an important preventive measure. A polyp is not visible on conventional ultrasonography, but on HS it can be seen as a solid moderately echogenic mass, which is fixed to the bowel wall and can thus be distinguished from faecal material. We managed to demonstrate two polyps, and rule out their infiltration into lower layers. Two masses that met all morphological criteria of polyps on HS were not confirmed on CS, but we were unable to follow the previously mentioned advice of Laufer and Thoeni[17] because the patients did not consent to double-contrast barium enema. Using HS, we overlooked six polyps, four of them less than 5 mm in diameter and two of 7 mm. The number of polyps was too small to be statistically representative, but the results are comparable to data for small series.[17] In large series, Limberg diagnosed polyps of more than 7 mm with a sensitivity

of 91 % and a specificity of 100 %, and polyps of less than 7 mm with a sensitivity of 25 % and a specificity of 97 %. The detection of polyps smaller than 7 mm is thought to be of minor clinical importance, since the likelihood of colorectal cancer in patients with small polyps is the same as in the population at large.[10] An interesting comparison of HS and double-contrast barium enema was made by Candia and co-workers who found HS to be less sensitive (80 % vs. 92 %) but more specific (100 % vs. 92.8 %).[24] CS gives false negative results in 15 % of cases, yet its advantage over HS and barium enema lies in the possibility of removing the polyps found.

We diagnosed two cases of diverticula, appearing as small luminal protrusions filled with gas and faecal material and therefore highly echogenic. A successful detection of diverticula by HS has been reported only by Limberg.[29] In the patient with known Crohn's disease, HS correctly identified three areas of stenosis. The result was confirmed at surgery, CS having failed because of pain. On HS, the affected segments of the gut wall were appreciably thickened and moderately echogenic (scarring associated with chronic inflammation). The normal wall architecture and haustrations were not visible. We had no cases of ulcerative colitis. Limberg found HS to be significantly more sensitive than conventional ultrasound for the diagnosis of Crohn's disease (96 % vs. 71 %) and ulcerative colitis (91 % vs. 62 %). He also found HS to be highly specific for both conditions (100 % for Crohn's disease and 98 % for ulcerative colitis). Using HS, he managed to distinguish between the two conditions in 93 % of cases.[4,7-9,13-15]

We were able to compare the overall sensitivity (81 %) and specificity (92 %) of HS in our patients with the data from another study, where a sensitivity of 67 % and a specificity of 96 % were obtained.[17] The feasibility of HS in our patients was comparable to that observed by several other authors[16,17,19,30] and inferior to the results reported by Limberg whose patients had no problems with the instillation and retention of water.[8,13-15] With the exception of a study where a patient experienced two vasovagal episodes and another developed diaphoresis,[19] no authors have encountered any complications using HS, which agrees with our experience. The average duration of the examination in our patients (15 minutes) was comparable to that reported by other authors. The retention of water caused the patients some discomfort, but apart from that they evaluated the examination as painless, whereas CS and barium enema were both described as painful. HS is thus comparable in usefulness to double-contrast barium enema, over which it has the advantages of not involving ionising radiation, being better tolerated by patients, being a cross-section imaging method and being feasible in the acute stage of inflammation.31 Its shortcoming is the inability to display adequately the rectum. It can be used in place of colonoscopy when the latter fails for subjective reasons, either on the part of the patient or the colonoscopist, or because of an objective problem, such as stenosis or acute inflammation. The main limitation of HS lies in the fact that it is technically very demanding and can therefore be performed only by a select group of highly experienced sonologists. We believe this to be the main reason for the limited popularity of HS despite the excellent results reported by its users.

Conclusions

With HS we correctly diagnosed tumours and polyps, diverticula and stenoses in Crohn's disease, and evaluated the condition of anastomoses after colonic resection. No complications were encountered, and the examination was well tolerated by the patients. HS is comparable in usefulness to double-contrast barium enema. The main advantages of HS are the absence of ionising radiation and the

absence of pain, while its main limitation lies in the technical demands placed on the sonologist.

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