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Diagnostic Potential of Magnetic Resonance Imaging in Chronic Abdominal Pain

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Chronic abdominal pain · Nonspecific abdominal pain · Magnetic resonance imaging · Diagnosis

Abstract
Introduction: About half of the adult patients suffering from chronic abdominal pain may have no organ-related cause. Our purpose was to evaluate the additional information of magnetic resonance imaging (MRI) in diagnosing the underlying organic causes of such pain. ***Methods:*** We performed retrospective audit of 636 consecutive abdominal MRI in patients suffering from nonspecific abdominal pain (NSAP) during years 2014–2017. Medical history, clinical examination, endoscopy reports, and the results of MRI were compared in all patients. The hypothesis was that MRI increases markedly the diagnostic specificity of patients' symptoms. ***Results:*** The mean age of patients was 66 ± 14 years and 60 percent were females. Duration of abdominal pain ranged from 1 month to 30 years (median 1.1 ± 4.0 years). Concurrently with abdominal MRI ($n = 636$), also ultrasound ($n = 106$, 17%), colonoscopy ($n = 222$, 35%), and gastroscopy ($n = 217$, 34%) were performed. Abdominal MRI revealed additional information in 161/636 (25%) of NSAP patients. Spinal and pelvic bone abnormalities ($n = 107$) and malignant tumors ($n = 31$) were the most significant organ-specific findings changing the treatment algorithm. ***Conclusions:*** When computerized tomography is not available in outpatient clinics, abdominal MRI increases markedly diagnostic specificity and alters the treatment in 1 of 4 patients suffering from NSAP. Abdominal MRI is therefore suggested for patients suffering from severe symptoms of NSAP.

Background

Chronic abdominal pain is defined as pain lasting over 1 week in distinction from acute abdominal pain lasting from 6 h to 7 days [1, 2]. Many functional and organic structural diseases (like gallstones) cause chronic abdominal pain [3–5]. Depending on patient's age, the most common diagnoses are nonorganic, such as functional dyspepsia, irritable bowel syndrome (IBS), or functional abdominal pain syndrome accounting for 30–80% of cases [1–6]. Together, these conditions affect approximately 1 in 4 people in the United States [7]. Most common organic diseases include gastroesophageal reflux disease, di-

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verticular disease in colon, cholelithiasis, chronic pancreatitis, mesenteric ischemia, hernias, intra-abdominal adhesions, or abdominal wall pain [8–15].

Evaluation in patients with chronic abdominal pain begins with history taking, clinical, and laboratory examinations. Gastroscopy is usually recommended once for investigating upper abdominal dyspeptic symptoms and colonoscopy in lower abdominal, constipation- or diarrhea-predominant IBS. Diagnostic imaging is often needed to give additional information in gut-related diseases and to rule out organic causes of pain in extraintestinal organs. If imaging is deemed necessary, the symptoms and clinical findings should direct the selection of the appropriate imaging modality. In outpatient practice, abdominal ultrasound (US) is commonly used as the primary imaging method, especially if cholelithiasis is suspected and if computed tomography (CT) is not available. Today, due to recent development in technology, increased availability and reduced costs, abdominal magnetic resonance imaging (MRI) can be considered a potential alternative to US and CT [16–18]. Serial MRI with the absence of ionizing radiation can definitely be useful in patients harboring a high risk of developing cancer (individuals with concerning family history/genetic predispositions). The present study was undertaken to evaluate our experience in using abdominal MRI in patients suffering from chronic nonspecific abdominal pain (NSAP) in 1 outpatient gastroenterological clinic. When CT imaging is not available, our hypothesis was that MRI gives additional information and increases markedly organ-specific diagnoses of NSAP.

Methods

Patients

All consecutive patients (n = 636) examined using MRI for chronic abdominal pain between March 2014 and December 2017 in 1 outpatient clinic were included in this retrospective study. Chronic NSAP was defined as periodic or continuous abdominal pain or symptom lasting over 1 week. Usually the pain history was longer lasting from 1 month to many years. The chronic NSAP was the diagnosis of exclusion [3]; that is, no other organic/structural disease was found after careful clinical examination, selectively performed laboratory, abdominal US, X-ray, gastroscopy, or colonoscopy examinations. The interpretation of all examinations was performed by senior specialist surgeons, gastroenterologists, or gynecologists. Indication for abdominal MRI was if the diagnosis of patient was not confirmed after other examinations or imaging studies (endoscopies, laboratory examinations, US, native X-ray). All available medical records were examined. The demographic data were also analyzed to detect any possible extrinsic factors causing abdominal pain (e.g., medication or previous trauma history). Checklist of items of cohort studies (STROBE statement; http://www.strobe-statement.org) was followed when reporting the data.

MR Examination

All patients were imaged using a 1.5 Tesla MRI system (GE Healthcare 1.5 T OPTIMA MR360, Milwaukee, WI, USA). The imaging protocols were selected and tailored according to clinical suspicions (upper, lower, or whole abdomen plus spine) as presented in the MRI referrals. For example, upper abdominal imaging protocols typically included coronal and axial T2-weighted sequences with and without fat suppression (T2 SSFSE single shot fast spin echo COR and AX TR 2,000 ms, TE 61–1,363 ms, slice thickness 6–7 mm), axial in-phase and out-of-phase sequences, and T1 fat-suppressed sequences with and without gadolinium enhancement, if deemed necessary (T2 fs RTr PROPELLER AX, TR 5,000 ms, TE 81 ms, slice thickness 7 mm and FIESTA BH AX TR 4.4 ms, TE Min Ful min 1.9, max 1.9, slice thickness 6 mm and 2D DualEcho AX TR 190, TE 2.2, TE2 4.8, slice thickness 7 mm). Magnetic resonance cholangiopancreatography with heavily T2-weighted 3D sequence in coronal oblique plane was also performed in every patient with upper abdominal or biliary symptoms (2D Thick slab MRCP TR 6,000 ms, TE 1,354 ms (1,300–2,000), slice thickness 50 mm, 3D MRCP RTr ASSET TR 5,000, TE minimum 600–1,000, slice thickness 1.6 mm). When spinal abnormality was suspected as a cause for radiating upper abdominal pain, sagittal T1, T2, and short tau inversion recovery sequences and axial T2 sequences of the thoracolumbar spine were acquired (STIR SAG TR 3,000–4,000 ms, TE 42 ms, TI 145 ms, slice thickness 4 mm). The duration of abdominal MRI was typically 40–50 min. Colonoscopy and esophagogastroscopy were performed using the routine technique with Pentax HD video system (i10 Pentax Endoscope System, Tokyo, Japan).

Image and Data Analysis

Imaging studies (MRI and US) were interpreted and reported by specialists in radiology. MR images were reviewed by 2 experienced abdominal radiologists, who were aware of clinical information on study participants. No blinded image analysis was performed. Recording of MR data was based on clinical reports. The data were analyzed by IBM Statistic SPSS-software version 25.0 (Chicago, IL, USA) using the Fisher's exact test or Student t test if needed. Data were reported as mean values ± SD. A p value lower than 0.05 was regarded as significant.

Results

The characteristics of patients with chronic abdominal pain are presented in Table 1. The mean age of patients was 66 ± 14 years and 60% (385/636) were females. Duration of abdominal pain ranged from 1 month to 30 years (median 1.1 ± 4.0 years). Chronic abdominal pain was most frequent indication for MRI (79%). Pain or other abdominal symptoms were more frequently observed in the upper abdomen (35%) than in the lower abdomen (28%). Fear of malignancy with a high risk of developing cancer, that is, the individuals with concerning family his-

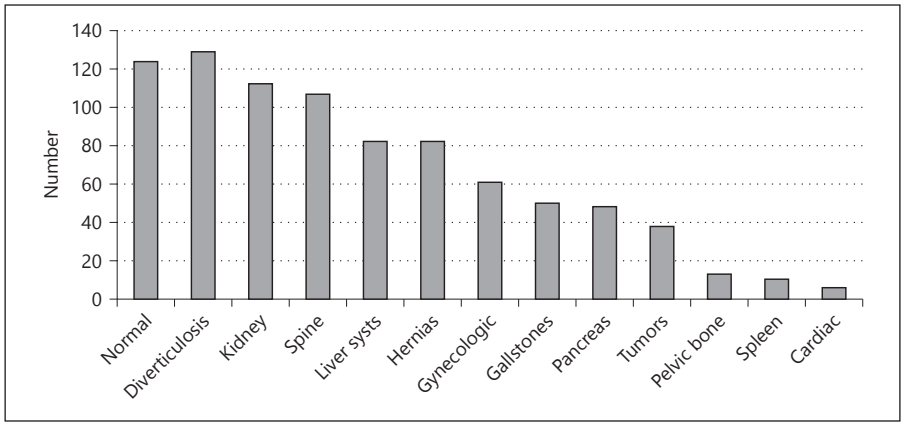

Fig. 1. MRI findings of patients having chronic abdominal pain. Most of the hepatic, urological, and gynecological MRI findings were benign cysts.

Table 1. Demographic data of patients with chronic abdominal pain (n = 636)

Variable	Number of patients (%)
Age, years, mean ± SD, median (range)	66±14 (7–95)
Gender, males/females	251/385 (40/60)
Duration of abdominal symptoms, years, mean ± SD	1.1±4.0 (range from 1 month to 30 years)
Indication of MRI	
Upper abdominal pain	222 (35)
Lower abdominal pain	175 (28)
Diffuse pain	100 (16)
Cancerofobia[1]	103 (16)
Infection	16 (2.5)
Trauma	4 (0.6)
Other	16 (2.5)
Simultaneous US	106 (17)
Colonoscopy	222 (35)
Gastroscopy	217 (34)

[1] Associated with positive family history, unintended weight loss, abdominal bloating, and so on.
MRI, magnetic resonance imaging; US, ultrasound.

tory/genetic predispositions, was a reason for MRI in 103 (16%) cases. Simultaneously with abdominal MRI, also US (17%), colonoscopy (35%), or gastroscopy (34%) was performed in the selected group of patients (Table 1).

Abdominal US (n = 106) revealed 6 patients with gallstones, 16 liver cysts, 7 renal cysts, 3 hernias, and 2 ovarian cysts. All MRI findings are presented in Figure 1 and Table 2. Multiple abdominal MRI studies were performed in 38 patients, usually because of disabling pain syndrome. MRI was considered normal in 124 cases (19%, Table 2). Most common MRI abnormalities were asymptomatic cysts (hepatic, renal, ovarian), colonic diverticular disease, spinal abnormalities, and various occult hernias. Majority of the MRI findings were probably coincidental not related to abdominal symptoms (Table 2). For example, most of the hernias, hepatic, renal, and ovarian cysts were probably asymptomatic.

The causal role of MRI finding related to pain was most evident in acute or subacute osteoporotic spinal fractures presenting edema in MRI and radiating pain to the upper abdomen (Fig. 2), colonic diverticulitis (Table 2, edema adjacent to bowel), and in the majority of malignant tumors (Fig. 3). As a cause of radiating upper abdominal pain, osteoporotic fractures of thoracic spine were more common in elderly females. Abdominal MRI revealed significant additional information changing the treatment strategy in 161/623 (26%) of patients. Spinal (n = 107) and pelvic (n = 13) bone abnormalities (19%) and malignant tumors (n = 31, 5%; Table 3) were the most significant MR findings increasing diagnostic value of MRI.

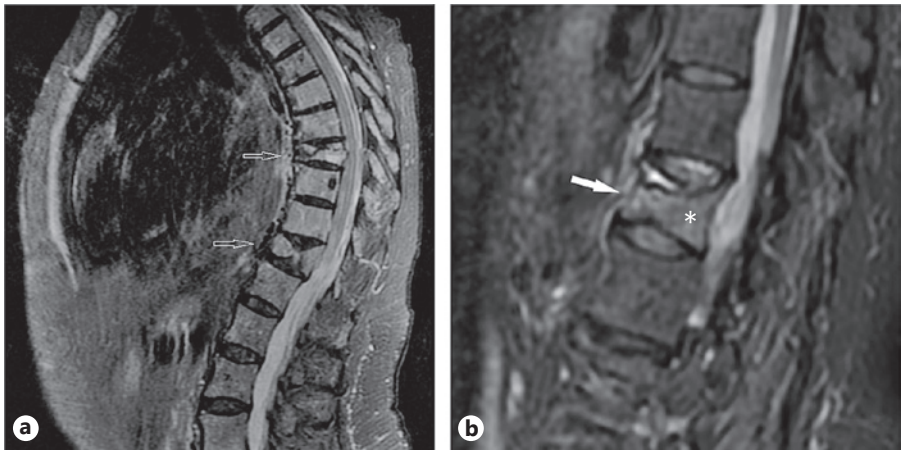

Fig. 2. Osteoporotic vertebral body compression fractures in 2 different patients. **a** Sagittal short tau inversion recovery image reveals compressions in T8 (arrow) and T11 (arrows) vertebral bodies. A hint of high signal intensity consistent with edema can be seen in the dorsal part of the T8 body and prevertebral soft tissue (upper arrow), indicating a fairly fresh fracture. Since there is no detectable edema in the T11 body, this can be considered an old compression. **b** Consistent with a fresh compression fracture (white arrow), remarkable diffuse bone marrow edema is visualized as high signal intensity in the T12 vertebral body (asterisk) in sagittal T1 image.

Table 2. MRI findings of patients (%) and possible relationship to chronic abdominal pain

MRI	Number of patients (%)	Possible cause of symptoms
Normal	124 (19)	
Hepatobiliary	144 (23)	
Cysts	82 (13)	1
Gallstones	50 (8.0)	11
Tumors	12 (1.9)	5
Colon diverticulosis	117 (18)	83
Acute diverticulitis	12 (1.9)	12
Urological	112 (18)	
Cysts	100 (16)	1
Tumors	12 (1.9)	5
Spinal	107 (17)	57
Hernia	82 (13)	12
Inguinal	39 (6.1)	
Umbilical/epigastric	31 (4.9)	
Hiatal	14 (2.2)	
Gynecological	61 (9.6)	
Ovarian cysts	28 (4.4)	
Uterine (myomas)	26 (4.1)	
Ovarian tumors	7 (1.1)	5
Pancreatic	48 (7.5)	
IPMN[1]/cysts	36 (5.7)	
Tumors	7 (1.1)	5
Chronic pancreatitis/stones	6 (0.9)	6
Pelvic bone abnormality	13 (2.0)	13
Splenic	10 (1.6)	
Cardiac	6 (0.9)	

[1] IPMN means intraductal papillary mucinous neoplasm.
MRI, magnetic resonance imaging.

Discussion

The major finding in our study was that abdominal MRI provides valuable additional information in about 25% of patients suffering from chronic NSAP syndrome. MRI proved to be especially helpful in diagnosing radiating abdominal pain from spinal or other skeletal diseases. Colon diverticulitis, hernias, and gallstones were also among the most common organic causes of abdominal pain. Due to the superior soft tissue contrast compared to US, MRI is an ideal imaging modality for investigating the spine and soft tissue body parts. For example, bone marrow and soft tissue edema associated with fresh fractures and other pathologic processes in skeletal structures (Fig. 2), or thoracic intervertebral disc herniation, can be reliably detected with MRI [19]. One previous study pointed out that 18 out of 27 patients with chronic abdominal pain showed evidence of thoracic disc herniation in MRI as a reason for pain. Majority of these patients were previously diagnosed to have IBS [20]. MRI adds significant specificity in the diagnosis of these patients. It may even be possible to differentiate osteoporotic and malignant compression fractures with modern MRI applications [21, 22]. Computerized tomography is also a valuable imaging tool to detect musculoskeletal diagnoses of abdominal pain, but it is seldom available in outpatient clinics in our country.

The utility of MRI as a noninvasive method in detecting gallstones is well established previously, and it clearly outperforms US and CT in depicting ductal stones [23–25]. Compared to MRI, abdominal US has also limitations sometimes due to bowel gas or patient's obesity. Since there is no exposure to ionizing radiation, MRI is an optimal imaging modality especially when radiation exposure is of concern, that is, for young and pregnant patients. However, dedicated examination protocols

Fig. 3. Fat-suppressed T2-weighted image in axial plane shows a large adenocarcinoma of the pancreatic body (arrows). The tumor encases the celiac trunk, common hepatic artery, and splenic artery (arrowheads).

Table 3. Chronic abdominal pain originating from malignant tumors and the spine

MRI finding	Number of patients (%)
Malignancy	31 (4.9)
Liver	6
Pancreas	5
Ovarial	5
Lymphoma	5
Renal	4
Miscellaneous[1]	6
Spinal	107 (17)
Fresh fractures	49
Spondyloarthrosis	51
Disc prolapse	3
Tumors	4

[1] Includes breast (n = 1), stomach (n = 1), colon (n = 2), and prostate (n = 2) cancers.

MRI, magnetic resonance imaging.

based on rather specific suspicions of the cause of abdominal pain are required to gain the most useful information with MRI (e.g., spinal or hepatic reason). The treatment algorithm for MRI should include severe persistent abdominal pain lasting many weeks or months without any clinical evidence of gastric ulcer or reflux disease (gastroscopy-based diagnosis) or large bowel symptoms (colonoscopy-based diagnosis). MRI is particularly useful for the females suffering from lower abdominal or pelvic pain (gynecological, pelvic rim, or hip-related diseases), obese patients with small hernias, or upper abdominal radiating pain from thoracic spine (osteoporotic fractures). Contraindications for MRI include sometimes cardiac pace-makers or claustrophoby. In such cases, we recommend abdominal US on CT. Because imaging cost of MRI has been reduced markedly in outpatient clinics in Finland (currently EUR 300–400) compared to abdominal US (EUR 250–300), MRI may soon be number one imaging modality in patients with chronic NSAP. In many European countries, CT scans are only available in hospitals and not in outpatient clinics. Ionizing radiation of abdominal CT limits its use as primary imaging modality in NSAP in younger patients and females. At present, MRI is not routinely performed in our institution in patients with NSAP, but it is more frequently used than US.

In clinical setting, the abdominal symptoms are, unfortunately, often nonspecific and may be very difficult to characterize. The cause of the symptoms remains chronic NSAP if no serious or definite organic cause can ever be established. In fact, acute or chronic NSAP is a symptom although it is used as a diagnosis for abdominal pain. The patients with acute and chronic NSAP have been reported to use more health services than other populations [26], which makes them a challenging and economically important group [27]. Psychological factors have often been implicated, but little is known for certain of their role [28]. In previous follow-up studies, no single explanatory reason for NSAP has been found [3, 29]. During long-term follow-up, the most common findings in the patients with NSAP were lactose intolerance, depression, musculoskeletal pain, and biliary disease during over 20 years of follow-up [30]. In addition to endoscopy examinations, our experience supports to refer selected NSAP patient once to abdominal MRI to rule out organ-specific diseases.

A pivotal question concerning the NSAP patients is whether there is an underlying malignancy causing symptoms, as suggested earlier [31]. In the present study, a small number of cancers (5%) were detected in patients with NSAP. Due to the retrospective nature of our study, it was not possible to specify the quality and duration of symptoms resulting from the malignant process itself. Even if the few cases of malignancy could have explained some of the symptoms in the NSAP group, an underlying malignancy is clearly an uncommon cause for NSAP. Obviously, if chronic abdominal pain is accompanied by worrisome symptoms, for example, unintended weight loss, melena, bloody stools, or anemia, thorough investigations are needed to rule out malignancy. Application of MRI versus endoscopies should be tailored for patients with NSAP for likelihood of findings based upon patient his-

tory, physical examination, and laboratory findings. There are clearly instances where MRI would be a primary choice due to clinical suspicion (e.g., suspected hepatobiliary cancer, biliary disease other than simple gallstones) or patient population (younger females/pregnancy, children).

The weakness of our study was that the patient cohort was retrospective. The retrospective study design lowers its level of evidence. Except for the strong clinical suspicion, we could not always confirm that the MRI finding was causally related to the abdominal symptom. Obvious reasons for pain were fresh thoracolumbar fractures or malignancy, but for example pain related to colon diverticular disease without inflammatory edema or diffuse spondyloarthrosis was more difficult to prove. One weakness was also that we did not compare all MRI results to CT. In our country, CT imaging is available only in hospitals and not in outpatient clinics. Prospective comparative study of MRI versus CT or US would give more information of the diagnostic potential of these imaging modalities in chronic NSAP. Objective assessments of the gastric, small bowel, and colonic regional volumes are possible using MRI, and unique data emphasizing the differences in gut volumes and motility related to chronic pain syndrome may be now possible [32, 33]. Finally, we did not test cost-effectiveness of MRI in NSAP because we were more interested in additional diagnostic potential of MRI in chronic pain syndrome.

Conclusion

Abdominal MRI adds important clinical information in 1 of 4 patients suffering from NSAP when compared to other outpatient diagnostic modalities. Particularly osteoporotic fractures in thoracic spine may radiate to upper abdomen and diagnosed using MRI. The abdominal MRI is currently also cost-effective (EUR 300–400) outpatient imaging modality compared to CT or US in our country. More prospective comparative studies are needed to test cost-effectiveness and diagnostic accuracy of MRI compared to other abdominal imaging.

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Statement of Ethics

All imaging procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this type of retrospective study based on clinical reports, informed consent was not required from individual participants included in the study. The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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Author Contributions

P.P. and H.P.: carried out the data evaluation, participated in collecting data, and drafted the manuscript. T.-T.L. and A.F.: performed the statistical analysis and participated in radiological/figure design. T.-T.L. and A.F.: helped to draft the manuscript. All authors read and approved the final manuscript.

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