MRI in suspected appendicitis

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CHAPTER 8

Diagnostic accuracy and patient acceptance of MRI in children with suspected appendicitis

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ABSTRACT

Objective
To compare MRI and ultrasound in children with suspected appendicitis.

Methods
In a single centre diagnostic accuracy study children with suspected appendicitis were prospectively identified at the emergency department. All underwent abdominal ultrasound and MRI within 2 h, with the reader blinded to other imaging findings. An expert panel established the final diagnosis after 3 months. We evaluated the diagnostic accuracy of three imaging strategies: ultrasound only, conditional MRI after negative or inconclusive ultrasound, and MRI only. Significance between sensitivity and specificity was calculated using McNemar’s test statistic.

Results
Between April and December 2009 we included 104 consecutive children (47 male, mean age 12). According to the expert panel 58 patients had appendicitis. The sensitivity of MRI only and conditional MRI was 100% (95% confidence interval 92–100), that of ultrasound was significantly lower (76%; 63–85, *P*<0.001). Specificity was comparable among the three investigated strategies; ultrasound only 89% (77–95), conditional MRI 80% (67–89), MRI only 89% (77–95) (*P* values 0.13, 0.13 and 1.00).

Conclusion
In children with suspected appendicitis, strategies with MRI (MRI only, conditional MRI) had a higher sensitivity for appendicitis compared with a strategy with ultrasound only, while specificity was comparable.
INTRODUCTION
Ultrasound is most commonly used in the work-up of children with suspected appendicitis at the emergency department. Following a negative or equivocal ultrasound, performing additional abdominal computed tomography (CT) can improve diagnostic accuracy and thereby decrease the negative appendectomy rate. However, the use of CT is unattractive because of the ionising radiation exposure especially in young patients. To reduce the burden of ionising radiation caused by CT, some alternatives have been explored; recent studies show that low-dose CT protocols can reduce the radiation dose by 30% by means of automated exposure control software, without any loss in diagnostic image quality. Obviously this does not eliminate the risks associated with radiation completely. Some clinicians consider performing a diagnostic laparoscopy instead of CT in children with a negative or inconclusive ultrasound, but this technique is associated with substantial morbidity. Magnetic resonance imaging (MRI) is considered a safe alternative. Therefore abdominal CT is increasingly replaced by MRI in various imaging algorithm proposals. However, evidence of the diagnostic accuracy of MRI for suspected appendicitis and patient acceptance in children is scarce.

Studies performed in pregnant women and in adult patients from the general population already show a high accuracy of MRI for appendicitis. However, children have a different body composition from adults; in general they have less abdominal fat and physiologically abundant lymphoid tissue. Therefore, imaging characteristics of the appendix may be different. So far, two prospective studies have investigated the diagnostic accuracy of MRI in 20 and 42 children with suspected appendicitis, and showed a sensitivity of 100%.

The purpose of this study was to compare the diagnostic accuracy and tolerance of ultrasound and MRI in children with suspected appendicitis.

MATERIALS AND METHODS
The RADIANCE study (Research in Acute appendicitis and Magnetic resonance imaging) is a comparative diagnostic accuracy study performed at the Alkmaar Medical Centre, the Netherlands. In a fully paired and blinded study design three imaging strategies were compared in children with suspected appendicitis: (1) ultrasound only, (2) conditional MRI after negative or inconclusive ultrasound, and (3) MRI only. The study protocol was approved by the local Medical Ethics Committee before study initiation. The legal representatives of each patient gave written informed consent, as did the patients themselves if aged 12 and older. This study was registered at the Dutch trial register (NTR 1664).

Patients
Consecutive paediatric patients with suspected acute appendicitis who presented at the emergency department of a large teaching hospital were invited to participate in this study. Eligible patients were children (4–18 years) with clinically suspected acute appendicitis as determined by the attending surgeon based on medical history, physical examination and laboratory findings. Patients were either self-referred or were referred by their general
practitioner. Patients were included 7 days a week, 24 hours a day. Exclusion criteria were recent abdominal surgery (<6 weeks before inclusion) or contra-indications for undergoing MRI.

Imaging protocol
All consenting patients underwent abdominal ultrasound and abdominal MRI.

Ultrasound
Ultrasound was performed by radiology residents on Philips (Bothell, WA) iU22 ultrasound machines with 3- to 5-MHz and 4- to 9-MHz transducers and consisted of a complete examination of the abdomen, including the use of the graded compression technique [19]. Residents were at least in the second year of their radiology residency (>500 abdominal ultrasounds), and in all cases they were supervised by a general radiologist with at least 10 years of abdominal ultrasound experience (>10,000 abdominal ultrasounds).

MRI
MRI was performed using a 1.5-Tesla system (Magnetom Avanto, Siemens, Erlangen, Germany) with a phased-array body coil for optimal signal-to-noise ratio. No oral or intravenous contrast agents and no sedatives were administered. Axial and coronal single-shot fast spin-echo pulse sequence (Half-Fourier Acquisition Single-shot Turbo spin-Echo sequence (HASTE), steady-state free precession technique (True FISP) with fat suppression and diffusion weighted imaging (DWI, including an apparent diffusion coefficient map) were performed (Table 1). A recent prospective study has demonstrated the value of DWI in patients with suspected acute appendicitis.20

<table>
<thead>
<tr>
<th>MRI protocol</th>
<th>True FISP</th>
<th>RARE</th>
<th>DWI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane</td>
<td>coronal and axial</td>
<td>coronal and axial</td>
<td>coronal and axial</td>
</tr>
<tr>
<td>Fat saturation</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Breath hold</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Number of slices</td>
<td>coronal: 23</td>
<td>axial: 72</td>
<td>coronal: 23</td>
</tr>
<tr>
<td>Slice thickness (mm)</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Slice distance (mm)</td>
<td>coronal: 0</td>
<td>axial: 0.3</td>
<td>0</td>
</tr>
<tr>
<td>Field of view (mm2)</td>
<td>coronal: 400 x 400</td>
<td>axial: 350 x 240</td>
<td>coronal: 350 x 350</td>
</tr>
<tr>
<td>Matrix</td>
<td>coronal: 230 x 384</td>
<td>axial: 148 x 256</td>
<td>coronal: 218 x 256</td>
</tr>
<tr>
<td>Time to repetition (ms)</td>
<td>coronal: 3.97</td>
<td>axial: 3.69</td>
<td>coronal: 938</td>
</tr>
<tr>
<td>Time to echo (ms)</td>
<td>coronal: 1.99</td>
<td>axial: 1.85</td>
<td>coronal: 85</td>
</tr>
<tr>
<td>Flip angle</td>
<td>70</td>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>PAT factor</td>
<td>2</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Imaging time per section (s)</td>
<td>coronal: 0.6</td>
<td>axial: 0.4</td>
<td>coronal: 0.9</td>
</tr>
<tr>
<td>Imaging time per volume (s)</td>
<td>coronal: 14</td>
<td>axial: 30</td>
<td>coronal: 22</td>
</tr>
<tr>
<td>Voxel size (mm)</td>
<td>coronal: 1.7 x 1.0 x 5.0</td>
<td>axial: 1.6 x 1.4 x 5.0</td>
<td>coronal: 1.6 x 1.4 x 1.5</td>
</tr>
</tbody>
</table>
studies were evaluated on a Picture Archiving and Communications System station (PACS, AGFA IMPAX version 4.5 service pack 5, Mechelen, Belgium). The MRI diagnosis was established by an abdominal radiologist [B.M.W.] with experience of >1000 abdominal MRI studies.

Image quality of ultrasound and MRI was graded on a three-point scale (non-diagnostic study, diagnostic study albeit with artefacts, diagnostic study of good quality). The following MRI features were recorded prospectively; appendix diameter, presence of peri-appendiceal infiltration, fluid, abscess, appendicolith, lymphadenopathy and restricted diffusion. The reader performing the ultrasound or assessing the MRI was blinded for the results of the other examination. The results of ultrasound and MRI were used for patient management. All patients with appendicitis were operated on within a few hours of diagnostic imaging.

**Patient acceptance**

All patients were asked to complete a questionnaire at two time points; directly after ultrasound and MRI (Appendix 1a) and 3 months later (Appendix 1b). The questionnaires were completed with or without the help of their legal representatives.

The questionnaires comprised multiple-choice questions using a facial scale, according to the affective facial scale of McGrath. Before the start of the study our questionnaires were validated by testing them on 30 children who had undergone an abdominal ultrasound. The questions addressed the patient’s experience concerning the duration, the associated pain and tolerance (e.g. the burden associated with ‘lying in a tunnel’) during the examinations. It also addressed the patient’s preference for any of the two examinations.

**Data collection and final diagnosis**

All information was anonymised and summarised in a structured case presentation by a clinician who had not been involved in the examination or management of the patients. This concerned data on history, physical examination, laboratory tests, the findings of ultrasound and MRI, surgery, histopathology and clinical follow-up of at least 3 months. The family physician of each patient was contacted to obtain follow-up information from outside our institution.

The final diagnosis was established by an expert panel consisting of two gastrointestinal surgeons [W.H.S. and A.P.J.H.] and one abdominal radiologist [B.M.W.] with long-term clinical experience in the management of children with suspected appendicitis. Each member of the panel individually evaluated all blinded cases, including 3 months’ follow-up based on the structured case presentation. Cases of disagreement were discussed at a consensus meeting and subsequently a final diagnosis was established.

**Data analysis**

We evaluated the accuracy of three imaging strategies in all the patients included by using combinations of the available imaging techniques: (1) ultrasound only, using the results of ultrasound only; (2) conditional MRI, using positive ultrasound results and MRI results if ultrasound was negative or inconclusive; (3) MRI only, using MRI results only. By comparison of the imaging results with the final diagnosis, estimates of sensitivity, specificity and predictive values for identifying appendicitis were calculated for each strategy, with corresponding 95% confidence.
intervals. Inconclusive test results were treated as negative in all calculations. Differences in sensitivity and specificity among the three imaging strategies were tested for significance using McNemar’s test statistic. Differences in positive and negative predictive values were tested using the Chi-squared statistic. \( P \) values below 0.05 were considered to indicate statistical significance.

Patient acceptance (duration, pain and tolerance) was compared between ultrasound and MRI using the Wilcoxon rank sum test. Chi-squared analysis was used to analyse the preference for a test as well as the patient’s experience of ‘lying in a very small tunnel’.

Sample size calculations indicated that we would need to enrol 100 patients to obtain sensitivity and specificity estimates for MRI with 95% confidence intervals not wider than 18% at an anticipated sensitivity of 90%\(^2\), and a prevalence of 45%.\(^23-26\) We included 4 more patients than necessary to compensate for possible dropout. All statistical analyses were done with SPSS software (SPSS, Chicago, IL, USA, version 20.0).

**RESULTS**

Between April 2009 and December 2009, 129 children with suspected appendicitis were eligible for participation in this study. In total 104 patients were included; 47 boys and 57 girls, their mean age was 12 years, with a range of 4 to 18 years. Sixty-one patients underwent appendectomy, 58 of whom had histopathologically proven appendicitis (42 flegmonous, 10 gangrenous and 6 perforated appendicitis). The final diagnosis that was established by the expert panel was acute appendicitis in 58 patients (prevalence 56%), non-specific abdominal pain in 17, gastro-enteritis in 13, mesenteric lymphadenitis in 7, gynaecological disorders in 6, and 3 other diagnoses (pneumonia, urinary tract infection and influenza). The mean white blood cell count in patients with acute appendicitis (14.9x10\(^9\)/L) was higher than in patients without acute appendicitis (9.9x10\(^9\)/L, \( P < 0.005 \)). CRP was not statistically different in the two groups (51.3 mg/L versus 29.4 mg/L, \( P = 0.058 \)).

The patient characteristics of the 25 children who were not included were comparable with the study group with regard to gender, age and presence of appendicitis.

Ultrasound and MRI were performed within a maximum of 2h in all patients. The total in-room time for ultrasound was approximately 15 min, while MRI had an in-room time of 12 min. The image quality of ultrasound was diagnostic in 101 patients, diagnostic with artefacts in 3 patients and non-diagnostic in 0, while the image quality of MRI was diagnostic in all patients and diagnostic with artefacts or non-diagnostic in none. The MRI features associated with appendicitis are presented in Table 2.

**Diagnostic accuracy for acute appendicitis**

Findings of ultrasound only were positive for appendicitis in 49 patients; compared with the final diagnosis this was correct in 44 patients (true positives). The final diagnoses of the 5 patients with false positive results were: non-specific abdominal pain (2), mesenteric lymphadenitis (1), gynaecological diagnosis (1) and terminal ileitis (1). Ultrasound only was inconclusive in 44 patients and negative in 11 patients; of these patients 14 had appendicitis as the final diagnosis (false negatives / missed cases of appendicitis). Ultrasound had a sensitivity of 76% (44/58; 95% confidence interval 63–85%), missing 24% of the appendicitis cases.
Conditional MRI (i.e. MRI following a negative or inconclusive ultrasound in 55 out of 104 patients) reduced the percentage of missed appendicitis to 0%. Of the 55 inconclusive or negative ultrasound cases, conditional MRI correctly diagnosed 51 cases (14 true positives (Figures 1 and 2), 37 true negative (Figure 3) and led to 4 additional false positive results.

Magnetic resonance imaging only had sensitivity of 100% (58/58; 95%CI 92–100) and specificity of 89% (41/46; 95%CI 76–96). Five false positive cases on MRI only included 4 with non-specific abdominal pain and 1 appendiceal carcinoid at histopathology.

The estimates of diagnostic accuracy of all three imaging strategies are shown in Table 2. The sensitivity of conditional MRI and MRI only was significantly higher compared with ultrasound only (100% versus 75%, $P<0.001$). Specificity was comparable among the three investigated strategies: ultrasound only 89% (77–95), conditional MRI 80% (67–89) and MRI only 89% (77–95; $P$ values 0.13, 0.13 and 1.00). The positive predictive value of ultrasound only was comparable with the conditional MRI (90% versus 87%, $P=0.60$) and the MRI only strategy (90% versus 92%, $P=0.68$), whereas the negative predictive value was not (ultrasound only compared with conditional MRI 75% versus 100%, $P=0.00$, and compared with MRI only, 75% versus 100%, $P<0.001$).

Table 2. Presence of MRI features associated with appendicitis

<table>
<thead>
<tr>
<th>MRI feature</th>
<th>Within patients with appendicitis n (%)</th>
<th>Within patients without appendicitis n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix visualised</td>
<td>57/57 (100%)</td>
<td>36/46 (78%)</td>
</tr>
<tr>
<td>Enlarged appendix (&gt;6mm)</td>
<td>53/58 (91%)</td>
<td>10/46 (22%)</td>
</tr>
<tr>
<td>Peri-appendiceal infiltration</td>
<td>48/57 (84%)</td>
<td>5/46 (11%)</td>
</tr>
<tr>
<td>Peri-appendiceal fluid</td>
<td>52/56 (93%)</td>
<td>7/46 (13%)</td>
</tr>
<tr>
<td>Abscess</td>
<td>6/57 (11%)</td>
<td>0/46 (0%)</td>
</tr>
<tr>
<td>Appendicolith</td>
<td>21/56 (38%)</td>
<td>0/46 (0%)</td>
</tr>
<tr>
<td>Lymphadenopathy</td>
<td>48/56 (86%)</td>
<td>34/46 (74%)</td>
</tr>
<tr>
<td>Restricted diffusion</td>
<td>56/58 (97%)</td>
<td>6/46 (13%)</td>
</tr>
</tbody>
</table>

Figure 1. A 17-year-old boy with 36-h abdominal pain and CRP of 87mg/L. At ultrasound the appendix was not visualised (not shown). Axial HASTE (a) showed a thickened appendix (13 mm, arrow) laying deep within the pelvis and some free fluid (arrowhead). Axial DWI (b) image showed restricted diffusion of the thickened appendix (arrow). Surgery revealed acute appendicitis.
Patient acceptance

In total, 52 out of 104 participants (50%) returned the questionnaire directly after the ultrasound and MRI. In these 52 questionnaires, 277 of the 312 questions (89%) were suitable for evaluation. The second questionnaire after 3 months was returned by 59 out of 104 participants (56%), and 135 of the 177 questions (76%) within these questionnaires were suitable for evaluation.

Significantly more patients experienced MRI as having a longer duration than ultrasound (58% versus 21%, \( P<0.005 \)), while more patients experienced ultrasound as being more painful than MRI (77% versus 10%, \( P=0.005 \)). Tolerance of MRI was comparable with that of ultrasound (53% versus 34%, \( P=0.754 \)). Most of the patients did not experience lying in the MRI gantry as burdensome (67.3% versus 32.7%, \( P=0.005 \)). There was no significant difference in preference for ultrasound or MRI directly after the examinations (44.2% versus 55.8%, \( P=0.405 \)) or 3 months after the examinations (48.2% versus 51.8%, \( P=0.789 \)).
DISCUSSION

This study showed that MRI only and conditional MRI after negative or inconclusive ultrasound have a higher sensitivity than ultrasound only in children with suspected acute appendicitis, while specificity was comparable. The positive predictive value of ultrasound is comparable to that of MRI. Therefore a strategy wherein ultrasound is the first step, followed by MRI in cases of negative or inconclusive findings seems profitable. Further studies are needed to evaluate if this strategy is cost effective. The tolerance of ultrasound and MRI was comparable and there was no significant difference in preference for either technique.

We need to address some limitations of our study. First, ultrasound was performed by supervised residents, while MRI was read by an experienced reader. Although the positive predictive value of ultrasound performed by a radiological resident was previously found not to be significantly different from that of a radiologist, this could have introduced a systematic bias to the study against the use of ultrasound for appendicitis in children.

Second, the results of ultrasound and MRI were used for patient management and were part of the reference standard, which can inflate diagnostic accuracy. Also, the members of the expert panel had been involved in patient management. Therefore we blinded all cases and the minimal interval between presentation and expert panel evaluation was 3 months.

Third, the patients completed the questionnaires with or without the help of their legal representatives. This approach introduced the possibility that the outcome about patient acceptance reflected the parent’s or guardian’s opinion rather than that of the patient. Also, the response rate of the questionnaires was relatively low. However, we still think that the findings are relevant, given the sizeable cohort, the paucity of data on patient experience for these two examinations and, to our knowledge, the absence of previous head to head comparisons of these techniques.

Fourth, the use of MRI for acute abdominal conditions is not yet daily practice in many hospitals. Until recently, MRI examination time was long, and young or non-cooperative patients had to be sedated to avoid motion artefacts. Currently, the examination time has been shortened substantially by the introduction of ultra-fast sequences, resulting in fewer

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity %, 95% CI</th>
<th>Specificity %, 95% CI</th>
<th>PPV %, 95% CI</th>
<th>NPV %, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TP/TP+FN</td>
<td>TN/TN+FP</td>
<td>TP/TP+FP</td>
<td>TN/TN+FN</td>
</tr>
<tr>
<td>Ultrasound only</td>
<td>76, 63-86</td>
<td>89, 76-96</td>
<td>90, 77-96</td>
<td>75, 61-85</td>
</tr>
<tr>
<td></td>
<td>44/58</td>
<td>41/46</td>
<td>44/49</td>
<td>41/55</td>
</tr>
<tr>
<td>Conditional MRI</td>
<td>100, 92-100</td>
<td>80, 66-90</td>
<td>87, 76-93</td>
<td>100, 89-100</td>
</tr>
<tr>
<td></td>
<td>58/58</td>
<td>37/46</td>
<td>58/67</td>
<td>37/37</td>
</tr>
<tr>
<td>MRI only</td>
<td>100, 92-100</td>
<td>89, 76-96</td>
<td>92, 82-97</td>
<td>100, 89-100</td>
</tr>
<tr>
<td></td>
<td>58/58</td>
<td>41/46</td>
<td>58/63</td>
<td>41/41</td>
</tr>
</tbody>
</table>

Values are percentages (95% confidence intervals), and absolute numbers below. TP = true positives. FN = false negatives, TN = true negatives, FP = false positives. PPV = positive predictive value, NPV = negative predictive value. Conditional MRI: MRI after negative or inconclusive ultrasound.
motion artefacts and reducing the need for sedation, even in the youngest patients. Our results are based on a single-centre study with good availability of MRI, and shows that MRI can be performed in an emergency setting. The availability of MRI has increased over the years and will most likely gain ground in the emergency setting.\textsuperscript{29}

Fifth, the MRIs were read by an experienced MRI reader. Most radiologists in clinical practice do not have the experience to match these results. A recent study showed that MRI readers can increase their diagnostic accuracy for acute appendicitis after training with MRI teaching cases.\textsuperscript{30} Therefore our results cannot yet be generalised to other situations.

In 1998, Hörmann et al.\textsuperscript{18} showed the ability of unenhanced MRI to detect appendicitis in 20 selected children. More recently two retrospective studies with a low prevalence of appendicitis (17% and 20%) showed a high sensitivity of 98–100% and specificity of 96–97% of MRI for acute appendicitis.\textsuperscript{31} Previously, only one prospective study has been performed in 42 unselected children with suspected acute appendicitis.\textsuperscript{17} In that study 3-T MRI detected 12 cases of acute appendicitis with 100% sensitivity at 99% specificity. No head-to-head comparison was performed among ultrasound, CT and MRI. In our study, we included 104 consecutive children with suspected acute appendicitis and compared strategies using ultrasound and unenhanced 1.5-T MRI. Our results confirm the previously shown high sensitivity of MRI (100%), while specificity was somewhat lower (89%).

The radiological criteria for appendicitis are well established for ultrasound and CT.\textsuperscript{32-34} In a recent study MRI features associated with appendicitis were identified in an adult population.\textsuperscript{35} This study found that an enlarged appendix diameter, peri-appendiceal fluid and restricted diffusion had the strongest association with appendicitis. In our study these features were also strong predictors for appendicitis.

The reported sensitivity of ultrasound has shown great variability and is substantially less than that of CT.\textsuperscript{36} For this reason a strategy with ultrasound only has not gained acceptance by paediatric surgeons and emergency physicians. Our study confirms a high percentage of missed cases of appendicitis with ultrasound only. CT is widely available, operator-independent and shows excellent accuracy in the diagnosis of appendicitis in children.\textsuperscript{36} In a randomised study additional CT following inconclusive ultrasound increased the sensitivity from 86 to 99%, while the specificity decreased from 95 to 89%.\textsuperscript{1} Although the selective use of CT in children can reduce radiation exposure\textsuperscript{37}, concerns about induction of malignancy due to radiation remain, especially in children.\textsuperscript{38}

Our findings on the diagnostic accuracy of conditional MRI are comparable with the reported conditional protocol with ultrasound followed by CT in cases of inconclusive results (sensitivity 99% and specificity 89%).\textsuperscript{1} We believe that MRI could play an important role as an alternative to CT in the diagnostic work-up of children with suspected appendicitis either as an initial diagnostic technique or after negative or inconclusive ultrasound findings. The sensitivity and specificity of the conditional MRI strategy was comparable with the MRI only strategy in our study.

Our study showed that ultrasound was experienced as being more painful than MRI and that MRI was experienced as being more time-consuming than ultrasound. Remarkably, most children did not regard lying in the MRI gantry as burdensome. There was no difference in tolerance between MRI and ultrasound, and the children did not prefer one examination to the other. Another study reported on the discomfort of 54 paediatric patients, aged 5–12, undergoing MRI;
the authors correspondingly concluded that discomfort can be regarded as minimal for more than half of children. This suggests that MRI is as acceptable as a diagnostic technique as ultrasound.

In conclusion, our prospective comparative study of 104 children with suspected acute appendicitis showed that MRI can be considered an alternative to CT or diagnostic laparoscopy in children with a negative or equivocal ultrasound, thus avoiding radiation exposure or use of intravenous contrast medium and possible morbidity of surgery.
REFERENCES


APPENDIX 1A

Questionnaire filled in 1 day after examinations

Questions about the ultrasound:

1. What did you think of the length of the ultrasound examination?
   □ very long
   □ long
   □ a little bit long
   □ not long
   □ not long at all

2. How painful did you find the ultrasound?
   ![Emojis showing pain levels from not painful to very painful]

Questions about the MRI

3. What did you think of the length of the MRI examination?
   □ very long
   □ long
   □ a little bit long
   □ not long
   □ not long at all

4. How painful did you find the MRI?
   ![Emojis showing pain levels from not painful to very painful]

5. Did you find it unpleasant to lie in the very small tunnel of the MRI? (claustrophobia)
   □ very unpleasant
   □ unpleasant
   □ a little bit unpleasant
   □ not unpleasant
   □ not unpleasant at all
6. If you had to undergo another examination, which examination would you prefer?
   - ultrasound
   - MRI

APPENDIX 1B
Questionnaire filled in 3 months after the examinations

1. How do you look back on the ultrasound you had to undergo?

   [Scale of 7 faces from happy to sad]

   - Not painful
   - Very painful

2. How do you look back on the MRI you had to undergo?

   [Scale of 7 faces from happy to sad]

   - Not painful
   - Very painful

3. If you had to undergo another examination, which examination would you prefer?
   - Ultrasound
   - MRI