Summary and conclusions
Chapter 1 provides a general introduction to this thesis focused on the use of ultrasound (US) in children with abdominal problems. The literature on the US appearance of the normal and diseased appendix in children is summarized. Subsequently, the literature on issues that are often a problem in assessing children with abdominal problems, in particular echogenicity of kidneys, intussusception, and enlarged lymph nodes, is also summarized. In relation to this, the goals of this thesis are to determine the ultrasonographic features of the normal appendix in asymptomatic children; to evaluate a new ultrasonographic classification of acute appendicitis with emphasis on secondary signs; to determine the frequency of increased echogenicity of the renal cortex in acutely ill children and to evaluate the assumed transient nature of this increased echogenicity; to evaluate the possibility to differentiate, based on clinical and/or ultrasonographic findings, between ileoileal and ileocolic intussusceptions in children; and to evaluate the significance of the presence of mesenteric lymph nodes in children with chronic abdominal pain and their possible association with intestinal parasitic infection.

In chapter 2, the US appearance of the appendix in children without clinical suspicion of acute appendicitis was prospectively evaluated. Between March 2003 and July 2003, 146 consecutive patients (62 boys and 84 girls; mean age, 7 years; age range, 2-15 years) without clinical suspicion of acute appendicitis were examined with US. Patients with cystic fibrosis and those with acute abdominal pain were excluded from the study. Outer diameters, mural thickness, and color Doppler flow were measured. Appendiceal lumen and surroundings of the appendix were determined. The overall diameter and mural thickness of the appendix were examined for relationship to age, weight, or height of the patient. For statistical analysis, the Mann-Whitney test, Student t test, and linear regression analysis were applied. In 120 (82%) children, the appendix was depicted with US; in 26 (18%) children, this was not possible. In 114 (95%) of the depicted appendices, the position was classical; we observed six (5%) retrocecal appendices. All appendices were compressible. Mean diameter of the appendix was 0.39 cm (range, 0.21-0.64 cm), and the mean mural thickness was 0.18 cm (range, 0.11-0.27 cm). The appendiceal lumen was empty in 74 (62%) children. The others were filled with fecal material, gas, or both.

In 75 (51%) of the 146 children, lymph nodes were present in the right lower quadrant of the abdomen. We found no relation between the age, weight, or height of the examined child and the overall diameter or wall of the appendix.

This chapter shows that a normal appendix can be depicted with US in 82% of the asymptomatic children. Lymph nodes (smaller than 1.0 cm) are a nonspecific finding in this study population.

In chapter 3, we evaluated the additional value of secondary signs in the diagnosing of appendicitis in children using US. From May 2005 to June 2006, 212 consecutive pediatric patients with suspected appendicitis were examined. Ultrasonographic depiction of the appendix was classified into four groups: 1, normal appendix; 2, appendix not depicted, no secondary signs of appendicitis; 3, appendix not depicted with one of the following secondary signs: hyperechoic
mesenteric fat, fluid collection, local dilated small bowel loop; 4, depiction of inflamed appendix.

We classified 96 patients in group 1, 41 in group 2, 13 in group 3, and 62 in group 4. Prevalence of appendicitis was 71/212 (34%). Negative predictive values of groups 1 and 2 were 99% and 100%, respectively. Positive predictive values of groups 3 and 4 were 85% and 95%, respectively. In groups 3 and 4, hyperechoic mesenteric fat was seen in 73/75 (97.3%), fluid collections and dilated bowel loops were seen in 12/75 (16.0%) and 5/75 (6.6%), respectively. None of the patients in whom the appendix could not be depicted and without secondary signs, developed acute appendicitis in one year follow-up. Thus, when the appendix can not be visualized at US and secondary signs of appendicitis are absent, one can safely rule out the diagnosis of acute appendicitis. On the other hand, when secondary signs are present in the right lower quadrant of the abdomen, even in cases of non-visualization of the appendix, the diagnosis is acute appendicitis.

In chapter 4, we determined the frequency of hyperechogenicity of renal parenchyma in children with acute abdominal illness and we evaluated the assumed transient feature of this hyperechogenicity. Between January 2005 and February 2006, 189 consecutive patients (112 boys and 77 girls; mean age, 10 years) presenting with acute abdominal pain were examined with US. Patients with a known history of renal disease and those with acute urinary tract infection were excluded from the study. Echogenicity of the renal cortex in comparison with adjacent liver was recorded. Renal cortex echogenicity was divided into three groups; group 1, renal cortex echogenicity less than liver parenchyma echogenicity; group 2, renal cortex echogenicity similar to that of liver parenchyma; and group 3, renal cortex echogenicity greater than that of liver parenchyma. Patients with hyperechogenicity were reexamined with US after 2 weeks or more. The final US diagnosis and clinical outcome were noted. Renal cortex echogenicity was equal to or greater than that of the liver parenchyma in 18% (n = 34) of 189 patients. Increased echogenicity of the renal cortex returned to normal in 2 or more weeks in all patients. Three patients had no follow-up. Clinical diagnoses were idiopathic acute abdominal pain (n = 74), appendicitis (n = 83), mesenteric lymphadenitis (n = 15), ileocecalitis (n = 7), gastroenteritis (n = 7), Crohn disease (n = 1), intussusception (n = 1), and pneumonia (n = 1). No concurrent renal disease was diagnosed. Hypothetically, the increased echogenicity of the renal cortex could been caused by the believed dehydrated state as a consequence of the acute illness. There is, however, no evidence for this. Increased echogenicity of the renal cortex in children with acute abdominal illness is a transient feature and does not indicate renal disease. When seeing increased renal cortex echogenicity, the radiologist should look thoroughly for non-renal abnormality such as acute appendicitis.
In chapter 5, we assessed the US features of ileoileal and ileocolic intussusceptions. The treatment of ileoileal intussusception in children differs from that of ileocolic intussusception. We reviewed the clinical and US findings of 27 cases with intussusception between September 2003 and July 2005. For statistical analysis the Mann-Whitney test was applied. Regarding ileoileal intussusceptions, 11 were documented in ten patients (7 boys, 3 girls; mean age, 3.1 years). Symptoms suggestive of intussusception were present in nine patients. The mean diameter was 1.5 cm (range, 1.1-2.5 cm) and length 2.5 cm (range, 1.5-6.0 cm). The intussusceptions were located in the paraumbilical region (n = 6), the right upper quadrant (n = 2), the right lower quadrant (n = 2), and the left lower quadrant (n = 1). Regarding ileocolic intussusceptions, 16 were documented in 14 patients (13 boys, 1 girl; mean age, 1.9 years). All patients had symptoms suggestive of intussusception. The mean diameter was 3.7 cm (range, 3.0-5.5 cm) and mean length was 8.2 cm (range, 5.0-12.5 cm). All intussusceptions were located in the right side of the abdomen. The difference in diameter and length between ileoileal and ileocolic intussusceptions was statistically significant (p < 0.05). US features, like diameter and length, are the main criteria for differentiation between the two types intussusception. When the diameter is more than 2.5 cm and the length is more than 5.0 cm, the intussusception is most likely to be ileocolic. Ileoileal intussusceptions resolve spontaneously, while ileocolic intussusception must be treated with enema or in rare cases with surgery. Clinical and ultrasonographic follow-up of the ileoileal intussusception is recommended.

The relation between mesenteric lymph nodes and parasitic intestinal infections in 224 children (89 boys, 135 girls; mean age, 9.0 years) with recurrent abdominal pain (RAP) are discussed in chapter 6. The children included in this study were subjected to an abdominal US and stool analysis. The presence of mesenteric lymph nodes and their size were evaluated. Lymph nodes were considered to be enlarged when they measured 8 mm or more. Organic abnormalities at abdominal US were noted. Fecal analysis was performed to detect the presence of parasitic infection. Mesenteric lymph nodes were depicted in all children. Lymph nodes were enlarged in only 6 (2.7%) of 224 patients. Parasitic infections were present in 56 (25.0%) of 224 patients with RAP. Enlarged mesenteric lymph nodes were not associated with the presence of parasitic intestinal infections in these children. Organic abnormalities (hepatic steatosis n = 2, mild ileoceccitis n = 1, echogenic particles in the bladder n = 1, suspected appendicitis n = 1, mild thickening of small bowel walls n = 2, hepatic enlargement n = 2, abnormal terminal ileum (suspected Crohn disease) n = 2) were seen in only 11 patients (4.8%) of the patient population, and in only half of these patients these organic abnormalities could be related to their chronic abdominal pain. This study showed, that there is no association between (enlarged) mesenteric lymph nodes and parasitic intestinal infection in children with RAP. And, in less than 5% of these children with RAP organic abnormalities can be depicted with US.
Conclusions

The following conclusions can be drawn:

1. The normal appendix can be depicted with ultrasonography in 82% of asymptomatic children (aged 2-15 years).
2. The normal appendix has a transversal diameter smaller than 0.6 cm in asymptomatic children.
3. The presence of mesenteric lymph nodes smaller than 1.0 cm is a non-specific finding in children without abdominal pain.
4. In the absence of secondary signs, acute appendicitis can be safely ruled out, even when the appendix is not depicted.
5. The presence of secondary signs of acute appendicitis in the right lower quadrant of the abdomen strongly indicates the presence of acute appendicitis in children with clinically suspected appendicitis.
6. Increased echogenicity of the renal cortex in children with acute illness is a transient finding, not associated with renal disease. In the majority of these patients abnormalities can be found in the abdomen using ultrasonography.
7. Ileoileal and ileocolic intussusceptions can be differentiated using ultrasonography. Diameter and length are the main criteria.
8. The presence of (enlarged) mesenteric lymph nodes is not associated with parasitic intestinal infections in children with recurrent abdominal pain. Organic abnormalities were depicted at abdominal ultrasonography in less than 5% of the patients.