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Systematic Review Article

A SONOGRAPHIC EVALUATION OF PEDIATRIC ACUTE ABDOMINAL PAIN: A SYSTEMATIC REVIEW

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Abstract: *Objective: In this study, our major concern is to evaluate the efficacy of ultrasonography with the help of previous literature. Ultrasonography is a major instrument to diagnose the initial abdomen pain but its sensitivity and specificity level are highly neglected in some studies. In this study, we aim to gather all the relevant data of the past decade and perform a systematic review on it. Methodology: For this study, we follow the Preferred Reporting Items guideline for conducting this systematic review analysis (PRISMA). We search electronic articles from 2011 to 2018 on PUB Med, online Willey library, and ScienceDirect and Research Gate site. Results: At the initial stage of gathering data, we found seven hundred and sixty-two articles with selected keywords. In the first screening, we excluded 262 duplicate articles and further screen out the rest of 498 articles. At the last stage, we found 24 articles that fulfilled the inclusion criteria and had adequate data on our topic. In the summary of weighted values of data, we observed that both sensitivity and specificity of the collected data are greater than 90%. Conclusion: A complete evaluation of acute abdominal pain needs time and experience to detect the morphological association of abdominal structures and their functioning. Ultrasonography assists in quick evaluation of the intestine wall with the association of laboratory and clinical outcomes.*

Keywords: Acute abdominal pain, Appendicities, necrotizing enterocolitis, Crohn's disease, Ulcer disease, IBD

Introduction

Acute abdominal pain is one of the most challenging issues among the pediatric population. Mostly, the abdominal pain of children is mild and not threatened their life still it needs proper evaluation (Aplry and Naish 1958). A mistaken diagnosis can have devastating results, either by not acting when action is called for or by performing unnecessary tests and procedures (Cervero, 1988). The major features of abdominal pain include acute appendicitis, enteric duplication cyst complications, intussusceptions, colon polyp, necrotizing enterocolitis, and inflammatory bowel disease. Acute appendicitis is considered one of the major causes of abdominal pain (John and Hollingsworth, 2011). Sometimes the intensity of pain requires surgical removal of the patient appendix (Di Serafino *et al*., 2017). Clinical diagnosis outcomes of acute appendicitis include a high tenderness of acute pain on the right iliac fossa along with fever, nausea, vomit. In the pediatric population, intestine tract polyps are highly observable which cause severe abdominal pain[3]. In the age group of 3-10 children are more prone to Juvenile polyps (Adolph and Bernabe, 2008). These lesions are usually between 1-3 cm in size and occurred in the rectosigmoid colon. Colonoscopy revealed that 50-60% pediatric population suffers from more than one polyp. In a 25% population cecum colon is the occurrence area polyps (de Ridder *et al*., 2007). These benign colon polyps are in isolation but the development of numerous polyps formed familial polyposis syndrome (Adolph and Bernabe, 2008; de Ridder *et al*., 2007).

Due to low cost and minimum radiation exposure, ESPGHAN revised criteria of diagnosis of inflammatory bowel disease declare ultrasound imaging as the best source of acute abdominal pain diagnosis (Chiorean *et al*, 2015). High-resolution the US helps to detect the complete information of the intestinal wall, and evaluate the intestinal wall thickness (Cervero, 1988). But on the other hand, the US has some drawbacks and only helpful to

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investigate complete information if combined with laboratory and clinical outcomes (Chaubal *et al*., 2006).

Objective

In this study, our major concern is to evaluate the efficacy of ultrasonography with the help of previous literature. Ultrasonography is a major instrument to diagnose the initial abdomen pain but its sensitivity and specificity levels are highly neglected in some studies. In this study, we aim to gather all the relevant data of the past decade and perform a systematic review on it.

Search strategy

For this study, we follow the Preferred Reporting Items guideline for conducting this systematic review analysis (PRISMA). We search electronic articles from 2011 to 2018 on PUB Med, online Willey library, and ScienceDirect and Research Gate site. We use keywords like diagnostic Imaging, diagnostic doppler ultrasound, diagnostic ultrasonographic radiology, medical Imaging, doppler ultrasound, sonography, efficacy of ultrasonography in acute appendicitis, efficacy of ultrasonography in necrotizing enterocolitis, efficacy of ultrasonography in small bowel obstruction, sensitivity and specificity values of ultrasonography, pediatric ultrasound for abdominal pain" to search relevant articles. With the help of keywords, we analyze the title, abstract aims, and objectives to extract the relevant data. We used Bolian operators for gathering information.

At the initial stage of gathering data, we found seven hundred and sixty-two articles with selected keywords. In the first screening, we excluded 262 duplicate articles and further screen out the rest of 498 articles. Later on, we omitted 402 articles with poor information on sonography and emphasis on CT imaging and 92 articles were further observed keenly to get desired information. At the last stage, we found 24 articles that fulfilled the inclusion criteria and had adequate data on our topic (Figure 1).

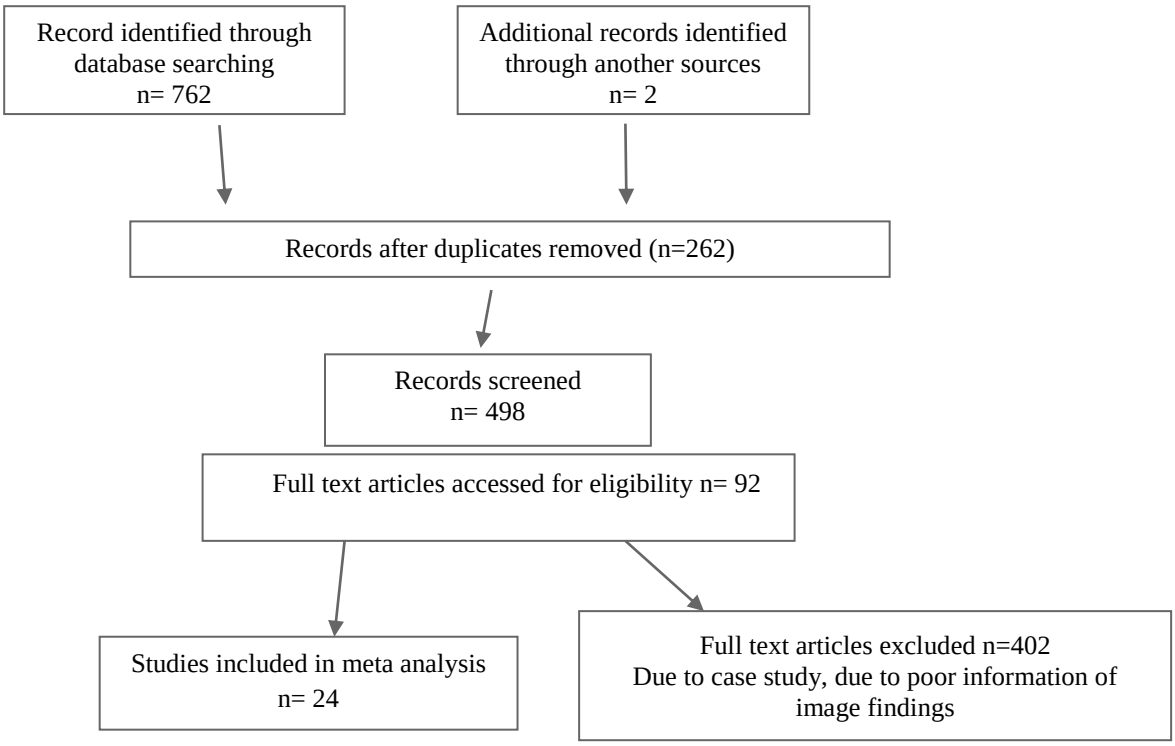

Figure 1. Prisma chart of meta analysis

Inclusion criteria

Articles with complete demographic information e.g., age range, type of disease, ultrasound specificity, sensitivity, prevalence disease among patients were included for this research. We gathered relevant articles from year 2011-2018. For conditional two studies from year 2000-202 were included to compare the efficacy of ultrasound machine in early years.

Exclusion criteria

Information in the form of posters, case studies with CT imaging, letters to editors, and articles with

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copied information was excluded from this study. Articles which were written in other than English language were not included for this research. On the behalf of keywords we found seven hundred sixty-two articles. The evaluation of our selected data was further done into two phases first we select the data based on abstract and title. Secondly, we examine the inner text of articles and include if they were eligible to fill the inclusion criteria of our study. We set 0.05 significant value of p in this research. We kept demographic information of patients like mean age and range, the sample size, author information, area of study in tabular form. We also observed the Ultrasound findings regarding sensitivity, specificity, TP, FP, FN, and TN of selected studies related to small inflammatory bowel disease, acute appendicitis, colon polyp, necrotizing enterocolitis.

Results

Pooling results of selected data depicts that 58.3% of prospective studies were conducted in past years. On the other hand, 37.5% retrospective and 4.14% of studies were conducted in past. Most of the studies were produced in the United States (33.3%). The pooling results of other countries are Canada (16.6%), China (8.33), India (4.16%), Korea (8.33%), Netherlands (8.33%), France (4.16%), Poland (4.16%), and Italy (4.16). After the categorization of data according to continents, this research found that most of the researches related to the pediatric population was conducted in Europe (45.8) (de Ridder *et al*., 2007; Garbi-Goutel *et al*., 2014), whereas the United States found the second number (33.3%) (Lam *et al*., 2014; Muchantef *et al*., 2013). Very less literature was produced from the Asian region (20.8%) (Civitelli *et al*., 2014) and no recent literature on sonography related to acute abdominal pain produced in the Middle East.

Table 1: Demographic findings of selected researches

Author	Study design	Region/ Country	Sample population N	Segment evaluated	Mean age and SD
Baldisserotto and Marchiori, (2000)	Prospective	USA	425	Appendicitis	Not mentioned
Han (2002)	Prospective	Korea	120	Appendicitis	not mentioned
Schuh *et al*., (2011)	Prospective	Canada	263	Appendicitis	not mentioned
de Riddle *et al*., (2007)	Prospective	Netherland	19	Crohn's disease	15
Muchantef *et al*., (2013)	Retrospective	USA	44	necrotizing enterocolitis	31 gestation age weeks
Garbi-Goutel *et al*., (2014)	Retrospective	France	95	necrotizing enterocolitis	28.7±2 GA wks
Yikilmaz *et al*., (2014)	Prospective	Canada	26	necrotizing enterocolitis	29 GA wks
Lam *et al*., (2014)	Prospective	USA	52	Appendicitis	20.2
Civitelli *et al*., (2014)	Prospective	Italy	50	ulcerative colitis	13
Ziech *et al*., (2014)	Prospective	Netherlands	24	Crohn's disease+ ulcerative colitis	14
Sivitz *et al*., (2014)	Prospective	USA	264	Acute Appendicitis	10.2
Wyrick eta l., (2015)	Retrospective	USA	112	Acute Appendicitis	not mentioned
Kim *et al*., (2015)	Prospective	Korea	115	Acute Appendicitis	not mentioned
Staryszak *et al*., (2015)	Case series	Poland	9	necrotizing enterocolitis	24–40 GA wks
Schuh *et al*., (2015)	Prospective	Canada	294	Acute Appendicitis	not mentioned
Prithviraj *et al*., (2015)	Prospective	India	60	necrotizing enterocolitis	30.5±0.5 GA wks
Ahmad *et al*., (2016)	Prospective	Canada	33	Crohn's disease + ulcerative colitis	15
He *et al*., (2016)	Retrospective	China	238	necrotizing enterocolitis	32 GA week
Wang *et al*., (2016)	Retrospective	China	144	necrotizing	33±3 GA wks

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				enterocolitis	
Dilman *et al*., (2016)	Prospective	USA	29	Crohn's disease	15
Palleri *et al* (2017)	Retrospective	Sweden	25	necrotizing enterocolitis	25.6 GA wks
Tsai *et al*., (2017)	Prospective	USA	41	Crohn's disease+ ulcerative colitis	14
Barber *et al*., (2017)	Prospective	United Kingdom	49	Crohn's disease + ulcerative colitis	4
Doniger and Kornblith, (2018)	Prospective	USA	40	Acute appendicitis	10.7

In the summary of weighted values of data, we observed that both sensitivity and specificity of the collected data are greater than 90%. We did not find any ultrasonographic values in necrotizing enterocolitis studies. This gap raises questions about the efficacy of Ultrasonography for neonatal cases. The pooling results of abdominal abnormalities revealed that past researchers were more interested to diagnose acute appendicitis cases among pediatric population (37.5%), a large variety of literature necrotizing enterocolitis (33.5%) did not have any relevant information regarding sensitivity and specificity of Ultrasonography. In selected year we observed Crohn's with ulcerative colitis (16.6%), Crohn's (8.3%), ulcerative colitis (4.16%).

Table 2: Ultrasonography findings of selected studies

Author	**No. of TP Finding %**	**No. of TN findings %**	**No. of FN findings %**	**No. of FP Finding %**	**Sensitivity %**	**Specificity %**	**Prevalence %**
Baldisserotto and Marchiori, (2000)	61	222	3	0	95	100	22
Han (2002)	1	11	0	0	100	100	8
Schuh *et al*., (2011)	10	26	2	1	83	96	31
de Riddle *et al*., (2007)					54	100	-
Muchantef *et al*., (2013)	Not mentioned	-	-	-	-	-	-
Garbi-Goutel *et al*., (2014)	Not mentioned	-	-	-	-	-	-
Yikilmaz *et al*., (2014)	Not mentioned	-	-	-	-	-	-
Lam *et al*., (2014)	33	6	0	13	83	89	63.8
Civitelli *et al*., (2014)	-	-	-	-	100	93	-
Ziech *et al*., (2014)	-	-	-	-	55	100	-
Sivitz *et al*., (2014)	72	166	13	13	83	89	32.2
Wyrick eta l., (2015)	17	33	3	3	85	92	36
Kim *et al*., (2015)	36	77	0	2	100	97	31
Staryszak *et al*., (2015)	Not mentioned	-	-	-	-	-	-

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Schuh *et al*., (2015)	12	10	5	13	71	43	46
Prithviraj *et al*., (2015)	Not mentioned	-	-	-	-	-	-
Ahmad *et al*., (2016)	Not mentioned	-	-	-	64	-	-
He *et al*., (2016)	Not mentioned	-	-	-	-	-	
Wang *et al*., (2016)	Not mentioned	-	-	-	-	-	-
Dilman *et al*., (2016)	Not mentioned	-	-	-	83	71	-
Palleri *et al* (2017)	Not mentioned	-	-	-	-	-	-
Tsai *et al*., (2017)	Not mentioned	-	-	-	67	78	-
Barber *et al*., (2017)	Not mentioned	-	-	-	81	95	-
Doniger and Kornblith, (2018)	15	21	1	3	83	89	40

Table 3: Prevelance of selected studies

Prevelance range	Mean	S.D	p value
8- 63.8	34.4	15.4	0 .07721

Table 4: Pool data for sensitivity and specificity of selected studies

Variables	Range	Mean	Standard deviations	p value
Sensitivity	54-100	80.4375	14.8	< .00001
Specificity	43-100	88.8	15.16	< .00001
Pool variance	223.525			0.97

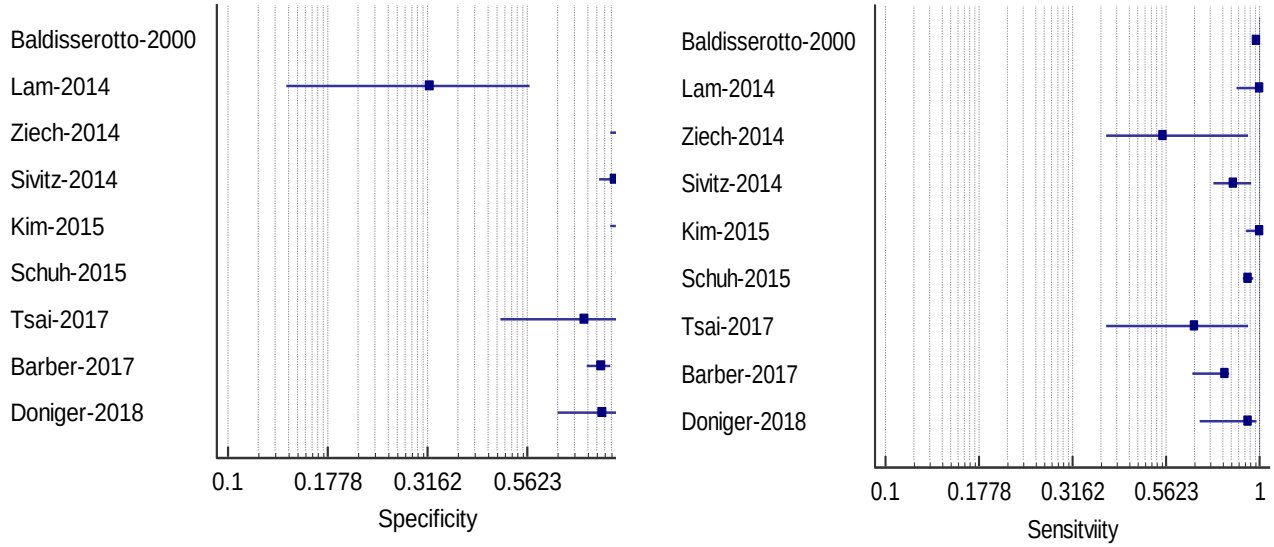

Figure 2. Forest plot of Sensitivity and specificity

Discussion

In our systematic review of the literature, we found the majority of the data concerned with the acute

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appendicitis cases. We tried to gather information related to other abdominal diseases like gastroesophageal reflux disease (GERD), pancreatitis, gallbladder disease, diverticulitis, and small bowel obstruction. Somehow we found literature on bowel obstruction with complete relevant information of sensitivity, specificity, TP, FP, FN, and TN findings (Figure 2). In the summary of weighted values of data, we observed that both sensitivity and specificity of the collected data are greater than 90%. The major features of abdominal pain were acute appendicitis, enteric duplication cyst complications, intussusceptions, colon polyp, necrotizing enterocolitis, and inflammatory bowel disease were the major concerns of this study. Acute appendicitis is considered one of the major cause of abdominal pain (John and Hollingsworth, 2011; Di Serafino *et al*., 2017). This organ exists on the front of the iliopsoas muscle and iliac vessels. Sometimes the intensity of pain requires surgical removal of the patient appendix. Clinical diagnosis outcomes of acute appendicitis include a high tenderness of acute pain on the right iliac fossa along with fever, nausea, vomit (John and Hollingsworth, 2011). Ultrasonography usually helps to predict the reason for abdominal pain with ambiguous symptoms and helps to suggest the treatment of the patient (Di Serafino *et al*., 2017). Appendix imaging in a normal situation is harder to gain. It is easier to get imaging of the appendix during indirect signs and pathological conditions (Trout *et al*., 2015; Xu *et al*., 2016). Pathological findings of acute appendicitis revealed that the normal human appendix lies between 6 mm in diameter. Appendix diameter more than 6 mm in terms of inflammation or due to fecal material present in appendicular lumen counted into appendicitis. Adipose hyper-echogenicity sign (AHS) is another sign to observe appendicitis. This sign emerged out after the inflammation of the appendicular wall due to the progressive involvement of peritoneal adipose cellular tissue in peri-appendicular fat among the lymph nodes. In Ultrasonography of acute appendicitis, fecaliths were observed in terms of echogenic foci with acoustic shadowing (Trout *et al*., 2015; Xu *et al*., 2016; Tulin-Silver *et al*., 2015). In the case of intensive inflammation, heterogeneous echogenicity and hyperemic changes in the peri-appendiceal tissue can be observed in color Dopler ultrasound[35]. The severe complications of the appendix may result in the smashing of the appendix which cannot be visualized easily with Ultrasonography due to decompression of appendix in many cases (Hwang, 2017; Trout *et al*., 2012; Tulin-Silver *et al*., 2015). In the first 3 years of childhood, very rare cases of appendicitis were observed but there is the possibility of sudden perforation which ends in appendicitis among this age group. Early detection of perforation through Ultrasonography helps to control severe complications (Doria, 2009). In the pediatric population, intestine tract polyps are highly observable. In the age group of 3-10 children are more prone to Juvenile polyps. These lesions are usually between 1-3 cm in size and occurred in the rectosigmoid colon[6]. Colonoscopy revealed that 50% -60% pediatric population suffers from more than one polyp. In a 25% population cecum colon is the occurrence area polyps. These benign colon polyps are in isolation but the development of numerous polyps formed familial polyposis syndrome. Clinical symptoms of polyps include abdominal pain with painless intestinal bleeding, mucous-purulent stools (Adolph and Bernabe, 2008; de Ridder *et al*., 2007). The imaging of juvenile polyps shows its location near the colon lumen and a hyper-echoic layer which formed cysts in the intestine wall. A very little amount of literature was found on the sensitivity and specificity of Ultrasonography due to gas obstruction (Parra and Navarro, 2008; Vitale *et al*., 2014).

Among newborn babies, necrotizing enterocolitis (NE) is the most commonly abdominal pain which sometimes ends in patient death (Neu *et al*., 1990). Necrotizing enterocolitis is usually defined as the inflammation of intestinal mucosa. It becomes ischemic after gas diffusion into the intestinal wall and portal venous system and ends into perforation and even death (Balance *et al*., 1990). It is highly associated with low birth weight, birth before 32 weeks of gestation period. All around the world, 2% to 7% of cases of NEC occur in all around the world (Battersby *et al*., 2018). Clinical symptoms of NEC include feeding, temperature, intolerance, vomiting, diarrhea, rectal bleeding, and even respiratory obstruction. Usually, X-RAY is considered as the

main imaging technique for NEC but from past years Ultrasonography plays a vital role in the early detection of NEC. Ultrasonography provides complete imaging of abdominal structures, bowel loop peristalsis, and detect peritoneal cavity fluid (Esposito *et al*., 2017).

Inflammatory bowel disease was another feature of our systematic review. It is usually described as a disorder that may be nonacute like enteritis, and mesenteric lymphadenitis and can occur in form of rare acute disorders like purpura, chronic inflammatory disease (Casciani *et al*., 2014; Casciani *et al*., 2014). Usually, it doesn't require any surgical intervention but hard to diagnose due to atypical symptoms and extra-intestinal functions like short stature, chronic anemia, unexplained fever, arthritis, mouth ulcer. Until now there is no specific reason that causes IBD in patients (Chiorean *et al*., 2015; Levine *et al*., 2014). Interestingly there is no single test to identify inflammatory bowel disorder in patients. Usually, it can be predicted through physical examination of the patient, patient history especially a family history of IBD, endoscopic intervention, serum, and fecal levels of the patient (Chiorean *et al*., 2015; Levine *et al*., 2014).

Due to low cost and minimum radiation exposure, ESPGHAN revised criteria of diagnosis of inflammatory bowel disease declare ultrasound imaging as the best source of IBD diagnosis[7]. High-resolution the US helps to detect the complete information of the intestinal wall, and evaluate the intestinal wall thickness (Chiorean *et al*., 2015). But on the other hand, the US has some drawbacks and only helpful to investigate complete information if combined with laboratory and clinical outcomes. US imaging evaluate 3-5mm wall thickness as mild cases of IBD, 6-9 mm as moderate, and > 9mm as critical cases of IBD (Biko *et al*., 2015). Ultrasonographic imaging further observed layered and non-layered categories of IBD disorder. Imaging observed indirect collaboration of submucous and appeared in terms of hyper-echoic which results in mucous inflammation in layered thickness (Chiorean *et al*., 2015). In the pediatric population, color Doppler ultrasound maximizes the sensitivity and specificity which helps to detect the hyperemia on the bowel wall and mesentery. It also helps to detect the location of inflammation and assist to evaluate fistula, abscesses, and ileus (Levine *et al*., 2014).

Conclusion

Due to small body habitus and less fat tissues in the abdominal wall and peritoneal cavity, ultrasonography imaging is the best source of diagnosis. Optimal positioning of device, proper transducer selection and the use of graded compression techniques enhance the visualization of the pathology of abdominal pain. A complete evaluation of acute abdominal pain needs time and experience to detect the morphological association of abdominal structures and their functioning. Ultrasonography assists in quick evaluation of the intestinal wall with the association of laboratory and clinical outcomes. It has ability to diagnose different abnormalities of abdominal region which leads to acute abdominal pain in the pediatric population at the initial stage.

Conflict of interest

There was no conflict of interest during study.

References

Adolph, V. R., & Bernabe, K. (2008). Polyps in children. *Clinics in colon and rectal surgery*, **21**(4), 280-285.

Ahmad, T. M., Greer, M. L., Walters, T. D., & Navarro, O. M. (2016). Bowel sonography and MR enterography in children. *American Journal of Roentgenology*, **206**(1), 173-181.

Apley, J., & Naish, N. (1958). Recurrent abdominal pains: a field survey of 1,000 school children. *Archives of Disease in Childhood*, **33**(168), 165.

Baldisserotto, M., & Marchiori, E. (2000). Accuracy of noncompressive sonography of children with appendicitis according to the potential positions of the appendix. *American Journal of Roentgenology*, **175**(5), 1387-1392.

Ballance, W. A., Dahms, B. B., Shenker, N., & Kliegman, R. M. (1990). Pathology of neonatal necrotizing enterocolitis: a ten-year experience. *The Journal of Pediatrics*, **117**(1), S6-S13.

Barber, J. L., Maclachlan, J., Planche, K., Furman, M., Crespi, D., Bab, N., & Beal, I. (2017). There is good agreement between MR enterography and bowel ultrasound with regards to disease location and activity in paediatric inflammatory bowel disease. *Clinical Radiology*, **72**(7), 590-597.

Battersby, C., Santhalingam, T., Costeloe, K., & Modi, N. (2018). Incidence of neonatal necrotising enterocolitis in high-income countries: a systematic review. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, **103**(2), F182-F189.

Casciani, E., De Vincentiis, C., Polettini, E., Masselli, G., Di Nardo, G., Civitelli, F., ... & Gualdi, G. F. (2014). Imaging of the small bowel: Crohn's disease in paediatric

patients. *World Journal of Radiology*, **6(**6), 313.

Cervero, F. (1988). Neurophysiology of gastrointestinal pain. *Bailliere's Clinical Gastroenterology*, **2**(1), 183-199.

Chaubal, N., Dighe, M., Shah, M., & Chaubal, J. (2006). Sonography of the gastrointestinal tract. *Journal of Ultrasound in Medicine*, **25**(1), 87-97.

Chiorean, L., Schreiber-Dietrich, D., Braden, B., Cui, X. W., & Dietrich, C. F. (2014). Transabdominal ultrasound for standardized measurement of bowel wall thickness in normal children and those with Crohnâ€™s disease. *Medical Ultrasonography*, **16**(4), 319-324.

Chiorean, L., Schreiber-Dietrich, D., Braden, B., Cui, X. W., Buchhorn, R., Chang, J. M., & Dietrich, C. F. (2015). Ultrasonographic imaging of inflammatory bowel disease in pediatric patients. *World Journal of Gastroenterology*, **21**(17), 5231. 7.5231.

Chiorean, L., Schreiber-Dietrich, D., Braden, B., Cui, X. W., Buchhorn, R., Chang, J. M., & Dietrich, C. F. (2015). Ultrasonographic imaging of inflammatory bowel disease in pediatric patients. *World Journal of Gastroenterology*, **21**(17), 5231.

Civitelli, F., Di Nardo, G., Oliva, S., Nuti, F., Ferrari, F., Dilillo, A., ... & Aloi, M. (2014). Ultrasonography of the colon in pediatric ulcerative colitis: a prospective, blind, comparative study with colonoscopy. *The Journal of Pediatrics*, **165**(1), 78-84.

de Ridder, L., van Lingen, A. V., Taminiau, J. A., & Benninga, M. A. (2007). Rectal bleeding in children: endoscopic evaluation revisited. *European Journal of Gastroenterology & Hepatology*, **19**(4), 317-320.

Di Serafino, M., Severino, R., Gullotto, C., Lisanti, F., & Scarano, E. (2017). Idiopathic renal infarction mimicking appendicitis. *Case reports in emergency medicine*, **2017**:8087315.

Dillman, J. R., Smith, E. A., Sanchez, R., DiPietro, M. A., Dehkordy, S. F., Adler, J., ... & Davenport, M. S. (2016). Prospective cohort study of ultrasound-ultrasound and ultrasound-MR enterography agreement in the evaluation of pediatric small bowel Crohn disease. *Pediatric Radiology*, **46**(4), 490-497.

Doniger, S. J., & Kornblith, A. (2018). Point-of-care ultrasound integrated into a staged diagnostic algorithm for pediatric appendicitis. *Pediatric Emergency Care*, **34**(2), 109-115.

Doria, A. S. (2009). Optimizing the role of imaging in appendicitis. *Pediatric Radiology*, **39**(2), 144-148.

Esposito, F., Di Serafino, M., Mercogliano, C., Ferrara, D., Vezzali, N., Di Nardo, G., ... & Zeccolini, M. (2019). The pediatric gastrointestinal tract: ultrasound findings in acute diseases. *Journal of Ultrasound*, 1-14.

Esposito, F., Mamone, R., Di Serafino, M., Mercogliano, C., Vitale, V., Vallone, G., & Oresta, P. (2017). Diagnostic imaging features of necrotizing enterocolitis: a narrative review. *Quantitative Imaging in Medicine and Surgery*, **7**(3), 336.

Garbi-Goutel, A., Brévaut-Malaty, V., Panuel, M., Michel, F., Merrot, T., & Gire, C. (2014). Prognostic value of abdominal sonography in necrotizing enterocolitis of premature infants born before 33 weeks gestational age. *Journal of Pediatric Surgery*, **49**(4), 508-513.

Han, T. I. (2002). Improved sonographic visualization of the appendix with a saline enema in children with suspected appendicitis. *Journal of Ultrasound in Medicine*, **21**(5), 511-516.

He, Y., Zhong, Y., Yu, J., Cheng, C., Wang, Z., & Li, L. (2016). Ultrasonography and radiography findings predicted the need for surgery in patients with necrotising enterocolitis without pneumoperitoneum. *Acta Paediatrica*,*105*(4): e151-e155.

Hwang, J. Y. (2017). Emergency ultrasonography of the gastrointestinal tract of children. *Ultrasonography*, **36**(3), 204.

Kim, C., Kang, B. S., Choi, H. J., Lim, T. H., Oh, J., & Chee, Y. (2015). Clinical application of real-time tele-ultrasonography in diagnosing pediatric acute appendicitis in the ED. *The American Journal of Emergency Medicine*, **33**(10), 1354-1359.

Kokurewicz, T., Ogórek, R., Pusz, W., & Matkowski, K. (2016). Bats increase the number of cultivable airborne fungi in the "Nietoperek" bat reserve in Western Poland. *Microbial Ecology*, **72**(1), 36-

Lam, S. H., Grippo, A., Kerwin, C., Konicki, P. J., Goodwine, D., & Lambert, M. J. (2014). Bedside ultrasonography as an adjunct to routine evaluation of acute appendicitis in the emergency department. *Western Journal of Emergency Medicine*, **15**(7), 808.

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Levine, A., Koletzko, S., Turner, D., Escher, J. C., Cucchiara, S., de Ridder, L., ... & Wilson, D. C. (2014). ESPGHAN revised porto criteria for the diagnosis of inflammatory bowel disease in children and adolescents. *Journal of Pediatric Gastroenterology and Nutrition*, **58**(6), 795-806.

Moon, S. M., Jung, H. K., Ko, K. H., Kim, Y., & Lee, K. S. (2016). Management of Clinically and Mammographically Occult Benign Papillary Lesions Diagnosed at Ultrasound-Guided 14-Gauge Breast Core Needle Biopsy. *Journal of Ultrasound in Medicine*, **35**(11), 2325-2332.

Muchantef, K., Epelman, M., Darge, K., Kirpalani, H., Laje, P., & Anupindi, S. A. (2013). Sonographic and radiographic imaging features of the neonate with necrotizing enterocolitis: correlating findings with outcomes. *Pediatric Radiology*, **43**(11), 1444-1452.

Neu, J., & Walker, W. A. (2011). Necrotizing enterocolitis. *New England Journal of Medicine*, 364(3), 255-264.

Palleri, E., Kaiser, S., Wester, T., Arnell, H., & Bartocci, M. (2017). Complex fluid collection on abdominal ultrasound indicates need for surgery in neonates with necrotizing enterocolitis. *European Journal of Pediatric Surgery*, **27**(02), 161-165.

Parra, D. A., & Navarro, O. M. (2008). Sonographic diagnosis of intestinal polyps in children. *Pediatric Radiology*, **38**(6), 680-684.

Prithviraj, D., Sandeep, B., Suresh, A., Balaraju, V., & Mondal, S. (2015). Comparison between X-ray and Abdominal Ultrasound Findings of Necrotizing Enterocolitis, its Usefulness in Early Diagnosis, Prognosis, and to Assess, is this is the Time to Change our View of Surgeon's Intervention According to the Bell's Criteria. *Prognosis, and to Assess, is this is the Time to Change our View of Surgeon's Intervention According to the Bell's Criteria*, **3**, 12.

Schuh, S., Chan, K., Langer, J. C., Kulik, D., Preto-Zamperlini, M., Aswad, N. A., ... & Doria, A. S. (2015). Properties of serial ultrasound clinical diagnostic pathway in suspected appendicitis and related computed tomography use. *Academic Emergency Medicine*, **22**(4), 406-414.

Schuh, S., Man, C., Cheng, A., Murphy, A., Mohanta, A., Moineddin, R., ... & Doria, A. S. (2011). Predictors of non-diagnostic ultrasound scanning in children with suspected appendicitis. *The Journal of Pediatrics*, **158**(1), 112-118.

Sivitz, A. B., Cohen, S. G., & Tejani, C. (2014). Evaluation of acute appendicitis by pediatric emergency physician sonography. *Annals of Emergency Medicine*, **64**(4), 358-364.

Staryszak, J., Stopa, J., Kucharska-Miąsik, I., Osuchowska, M., Guz, W., & Błaż, W. (2015). Usefulness of ultrasound examinations in the diagnostics of necrotizing enterocolitis. *Polish Journal of Radiology*, **80**, 1.

Trout, A. T., Sanchez, R., Ladino-Torres, M. F., Pai, D. R., & Strouse, P. J. (2012). A critical evaluation of US for the diagnosis of pediatric acute appendicitis in a real-life setting: how can we improve the diagnostic value of sonography?. *Pediatric Radiology*, **42**(7), 813-823.

Trout, A. T., Towbin, A. J., Fierke, S. R., Zhang, B., & Larson, D. B. (2015). Appendiceal diameter as a predictor of appendicitis in children: improved diagnosis with three diagnostic categories derived from a logistic predictive model. *European Radiology*, **25**(8), 2231-2238.

Tsai, T. L., Marine, M. B., Wanner, M. R., Cooper, M. L., Steiner, S. J., Ouyang, F., ... & Karmazyn, B. (2017). Can ultrasound be used as the primary imaging in children with suspected Crohn disease?. *Pediatric Radiology*, **47**(8), 917-923.

Tulin-Silver, S., Babb, J., Pinkney, L., Strubel, N., Lala, S., Milla, S. S., ... & Fefferman, N. R. (2015). The challenging ultrasound diagnosis of perforated appendicitis in children: constellations of sonographic findings improve specificity. *Pediatric Radiology*, **45**(6), 820-830.

Vitale, V., Di Serafino, M., Mercogliano, C., & Vallone, G. (2016). Giant colon polyp in a child with suspected inflammatory bowel disease: US findings. *Journal of Ultrasound*, **19**(1), 53-55.

Wang, L., Li, Y., & Liu, J. (2016). Diagnostic value and disease evaluation significance of abdominal ultrasound inspection for neonatal necrotizing enterocolitis. *Pakistan Journal of Medical Sciences*, **32**(5), 1251.

Wyrick, D. L., Smith, S. D., Burford, J. M., & Dassinger, M. S. (2015). Surgeon-performed ultrasound: accurate, reproducible, and more efficient. *Pediatric Surgery International*, **31**(12), 1161-1164.

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Yikilmaz, A., Hall, N. J., Daneman, A., Gerstle, J. T., Navarro, O. M., Moineddin, R., ... & Pierro, A. (2014). Prospective evaluation of the impact of sonography on the management and surgical intervention of neonates with necrotizing enterocolitis. *Pediatric Surgery International*, **30**(12), 1231-1240.

Ziech, M. L., Hummel, T. Z., Smets, A. M., Nievelstein, R. A., Lavini, C., Caan, M. W., ... & Stoker, J. (2014). Accuracy of abdominal ultrasound and MRI for detection of Crohn disease and ulcerative colitis in children. *Pediatric Radiology*, **44**(11), 1370-1378.