ABSTRACT

Objectives: Training healthcare physicians to perform intestinal ultrasound (IUS) during outpatient visits with equal accuracy as radiologists could improve clinical management of IBD patients. We aimed to assess whether a healthcare-physician can be trained to perform IUS, with equal diagnostic accuracy as experienced radiologists in children with IBD, and to assess inter-observer agreement.

Methods: Consecutive children, 6 to 18 years with IBD or suspicion of IBD, who underwent ileo-colonoscopy were enrolled. IUS was performed independently by a trained healthcare-physician and a radiologist in 1 visit. Training existed of an international training curriculum for IUS. Operators were blinded for each other’s IUS, and for the ileocolonoscopy. Difference in accuracy of IUS by the healthcare-physician and radiologist was assessed using areas under the ROC curve (AUROC). Inter-observer variability was assessed in terminal ileum (TI), transverse colon (TC), and descending-colon (DC), for disease activity (ie, bowel wall thickness [BWT] >2 mm with hyperaemia or fat-proliferation, or BWT >3 mm).

Results: We included 73 patients (median age 15, interquartile range [IQR]:13–17, 37 [51%] female, 43 [58%] with Crohn disease). AUROC ranged between 0.71 and 0.81 for the healthcare-physician and between 0.67 and 0.79 for radiologist (P > 0.05). Inter-observer agreement for disease activity per segment was moderate (K: 0.58 [SE: 0.09], 0.49 [SE: 0.12], 0.52 [SE: 0.11] respectively for TI, TC, and DC).

Conclusions: A healthcare-physician can be trained to perform IUS in children with IBD with comparable diagnostic accuracy as experienced radiologists. The interobserver agreement is moderate. Our findings support children with IBD with comparable diagnostic accuracy as experienced radiologists. The interobserver agreement is moderate. Our findings support children with IBD with comparable diagnostic accuracy as experienced radiologists.

Key Words: intestinal ultrasound, paediatric inflammatory bowel disease, point-of-care ultrasound

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is increasingly used in clinical practice. A practical obstacle for its use is, however, the need for a radiologist or US technician to perform IUS. Training nonradiologist healthcare physicians—such as gastroenterologists and paediatricians—to perform a point-of-care IUS (POCUS) during the outpatient clinic visit with equal accuracy as a radiologist would allow for a broader implementation of IUS and could improve clinical decision-making (2). Because of a lack of evidence, however, there is currently no consensus on how to train healthcare physicians (3). Several surveys show that this poses a barrier for paediatricians for learning to perform POCUS, and resistance from the radiology department to support POCUS because of this lack of evidence is part of this barrier (4–7). Comparing the diagnostic performance of a trained healthcare physician to a paediatric radiologist might help in eliminating this barrier. In this study, we assessed whether a trained healthcare physician can perform IUS, with an accuracy that is equal to an experienced paediatric radiologist. Our primary aim was to compare diagnostic performance of IUS by a trained healthcare physician and a paediatric radiologist, using ileocolonoscopy as reference standard. Our secondary outcome was the interobserver variability between both observers in children diagnosed with or suspected of IBD.

METHODS

This study was part of an ongoing study on the diagnostic test accuracy of IUS in paediatric IBD (the RAINBOW-study). The RAINBOW-study is a prospective cross-sectional study in 2 tertiary care centres in Amsterdam, the Netherlands. Consecutive patients, aged 6 to 18 years old who underwent an ileocolonoscopy for diagnosis or follow-up of IBD between August 2019 and June 2021 were enrolled. Patients with ongoing gastroenteritis or with history of surgical resection were excluded.

Ultrasound

The 2 IUS examinations were performed consecutively at the radiology department, on the same day, the day before, or at most within 7 days of the reference standard, by 1 trained healthcare physician (training is described in detail below) and 1 of 3 paediatric radiologists (all > 12 years of experience). All operators were blinded for each other’s IUS results, for the outcome of the reference standard and for clinical disease activity parameters. Patients were asked to take no solid food, carbonated beverages and milk for 4 hours before the US examination, as recommended by the ESPR/ESGAR guideline (8). The IUS examinations were performed with a Philips EPIQ 5 machine (Philips Healthcare, Best, the Netherlands), using a convex probe (2–9 MHz, C9-2, Philips Healthcare) for general screening and a linear probe (4–12 MHz, L12-4, Philips Healthcare) for measurements. The following bowel measurements were performed: bowel wall thickness (BWT) in millimetre (mm), measured from the lumen/mucosa interface to the muscularis/serosa interface in a noncontracted bowel loop, next to a haustation at the most severely inflamed part of every bowel segment. BWT was measured twice in the longitudinal plane and twice in the cross-sectional plane and the mean of these 4 measurements was used. For the RAINBOW-study, we performed measurements of the jejunum, ileum, terminal ileum, cecum, ascending-, transverse-, descending-, sigmoid colon and rectum; however, for this sub-study, we limited our analyses to the terminal ileum (TI) and the descending colon (DC), as these are 2 of the most prevalent disease locations respectively paediatric Crohn disease (CD) and ulcerative colitis (UC) and both have a relatively fixed anatomical position. In addition, we included the transverse colon in the analyses, as the anatomical position is more variable and we wanted to investigate the effect of this variable anatomic position on the interobserver analyses. The TI was identified near the psoas muscle and iliac vessels, just proximal of the iliocecal valve. The TC was identified caudally from the stomach. The DC was identified on the lateral left side of the abdomen. Other measurements included: bowel wall perfusion using colour Doppler (yes [ie, spots or more] or no, velocity rate: +/-10 cm/seconds), and presence of mesenteric fat proliferation, or so-called ‘fatty wrapping’ (yes or no). In addition, presence of complications (stenosis, fistula, and abscesses) were noted.

All measurements were noted on a prepiloted scoring form during the examinations and all operators received an instruction before the training on how to score.

Training of Physician

The healthcare physician (E.W.) was a physician working at the Department of Paediatric Gastroenterology, with no previous experience in performing ultrasound examinations. She followed the curriculum of the International Bowel Ultrasound Group, which consists of an introductory hands-on workshop, a 4-week part time hands-on training in an expertise centre and an advanced workshop including a final test (9). The 4-week hands-on training was followed at the Amsterdam IBD clinic and at the Gastroenterology Department of the Städtisches Klinikum Lüneburg, Germany. She performed 100 IUS examinations under the supervision of experienced ultrasonographers before the start of the study. In addition, she performed 20 IUS examinations at the Paediatric Radiology Department to gain experience with paediatric patients.

Reference Standards

The ileocolonoscopies were performed by the paediatric gastroenterologists of the participating centres and were videotaped. The videotapes were centrally read by 1 experienced paediatric gastroenterologist (B.K.) who was blinded for the IUS result. Disease activity was scored by the Simple Endoscopic Score for CD (SES-CD) (10) in case of CD and with the Mayo endoscopic sub score in case of UC.

Statistical Analyses

For the primary outcome, the difference in diagnostic performance of the healthcare physician and the paediatric radiologist was assessed by comparing areas under the receiver operating characteristics curve (AUROC) in all 3 segments using MedCalc (2021 MedCalc Software Ltd). The disease definition of activity assessed by IUS was a BWT >2 mm, in combination with at least 1 other sign of inflammation, or in case of a BWT >3 mm, with or without other signs of inflammation. For the SES-CD we used the cut-off ≥ 1 per segment as abnormal and for the Mayo score ≥ 1.

For interobserver agreement, Bland-Altman plots were used to display agreement on BWT. In addition, we categorized BWT in normal (0–2 mm), mildly increased (2–3 mm) and strongly increased (>3 mm). These categories were based on a systematic review on IUS measurements in healthy children (11) and on a systematic review on IUS in children with IBD (12). For agreement in assessing disease activity, we used the definition of an abnormal IUS described above. Kappa statistics were used for dichotomous variables and weighted Kappas for ordinal variables. Kappa values were judged as follows: < 0.0: poor; k 0.0 to 0.20: slight; 0.21 to 0.40: fair; 0.41 to 0.60: moderate; 0.61 to 0.80: substantial; >0.80: almost perfect (13). In case of continuous variables, systematic differences were assessed using the Wilcoxon signed ranked test.
for paired non-parametric data. Analyses were done using SPSS v.26.

Ethical Considerations

Informed consent was obtained from all patients ages between 12 and 18 years and all care givers of patients aged < 16 years. The study has been approved by the Institutional Review Board (number of approval: K1 B2019450) and complied to the Declaration of Helsinki.

RESULTS

We included a total of 73 patients between August 2019 and June 2021. The patient demographics are displayed in Table 1. The TI and TC could be measured by the healthcare physician in all cases and the DC was not identified in 1 case. The DC could be identified by the paediatric radiologist in all cases, and the TI and TC could not be identified in 1, respectively, 2 cases. In the TI, abscesses, fistula and stenosis were noted, respectively, 1, 0, and 3 times by the health care physician, and respectively, 1, 1, and 2 times by the paediatric radiologist. All complications were confirmed by MRE except for the stenosis in 1 patient who did not undergo MRE imaging. In other segments, neither of the operators noted complications.

Diagnostic Accuracy

The AUROC for detecting disease activity for all 3 bowel segments are displayed in Figure 1. The ileum could not be intubated in 5 patients, and these were thus excluded from the analysis of the ileum. There was no significant difference in AUROC between the health care physician and the paediatric radiologist for TI (0.71 [SE: 0.08, 95% CI: 0.59–0.82] vs. 0.79 [SE: 0.07, 95% CI: 0.67–0.88], P > 0.05), transverse colon (0.81 [SE: 0.06, 95% CI: 0.70–0.89] vs 0.75 [SE: 0.06, 95% CI: 0.63–0.85], P > 0.05), and descending colon (0.73 [SE: 0.06, 95% CI: 0.61–0.83] vs 0.67 [SE: 0.06, 95% CI: 0.55–0.78], P > 0.05), respectively (P > 0.05).

Interobserver Agreement

Bowel Wall Thickness

There was no significant difference between the BWT measurements of the healthcare physician and radiologist. The median [IQR] BWT was 2.22 [1.63–3.11] versus 1.92 [1.41–3.21] mm for TI (P = 0.22), 1.81 [1.52–2.49] versus 2.01 [1.53–2.49] mm for TC P = 0.62, and 1.89 [1.50–2.78] versus 2.04 [1.58–2.71] for DC (P = 0.43), for the healthcare physician and radiologists, respectively. As depicted in Figure 2, there was no systematic difference in BWT measurements, and for DC, the mean difference increased when mean BWT increased. The agreement in categorizing BWT (ie, 0–2, 2–3, >3 mm) was fair for TI (κ: 0.40 [SE: 0.09]), moderate for TC (κ: 0.47 [SE: 0.09]) and fair for DC (κ: 0.36 [SE: 0.09]) (Table 1, Supplementary Digital Content, http://links.lww.com/MPG/C755).

Doppler Signal

The agreement in assessing hyperaemia was moderate for TI (κ: 0.41 [SE: 0.10]), and fair for TC (κ: 0.32 [SE: 0.15]) and DC (κ: 0.34 [SE: 0.13]) (Table 2, Supplementary Digital Content, http://links.lww.com/MPG/C755).

Fat Proliferation

The agreement for presence of mesenteric fat proliferation was moderate (κ: 0.52 [SE: 0.11]) for TI and fair for TC (κ: 0.36 [SE: 0.5]) and DC (κ: 0.37 [SE: 0.16]) (Table 3, Supplementary Digital Content, http://links.lww.com/MPG/C755).

![FIGURE 1. Distribution of the different clinical presentation forms according to (A) age at diagnosis and (B) year of diagnosis.](image-url)
Overall disease Activity

The agreement for assessing disease activity per segment was moderate for each segment (κ: 0.58 [SE: 0.09], 0.49 [SE: 0.12], 0.52 [SE: 0.11], respectively for TI, TC, and DC) (Table 2).

DISCUSSION

This study shows that a healthcare physician can be trained to perform an IUS in children with IBD with an equal accuracy compared with an experienced radiologist, by following a currently available training curriculum. These results further support the introduction of POCUS as monitoring tool for disease activity in children with IBD.

This is the first study that performed a head-to-head comparison between a trained healthcare physician and an experienced radiologist, with regard to IUS. The diagnostic accuracy of trained healthcare physician in performing IUS has been studied before, mostly in the adult IBD population (14,15). None of these studies, however, compared their results to those of an experienced radiologist. Equal diagnostic accuracy of IUS by healthcare physician compared with radiologists was shown in other intestinal disorders in children, such as the detection of intussusception and appendicitis (16,17). Adding POCUS as noninvasive monitoring tool for detection of IBD activity could alter clinical decision-making (2). On the basis of our results, IUS performed by a trained healthcare physician will not negatively impact diagnostic accuracy in comparison to radiologist-performed IUS. The AUROCs in our study were not optimal, however.

TABLE 2. Agreement in assessing disease activity

|                         | Terminal ileum | Transverse colon | Descending colon |
|-------------------------|----------------|------------------|-----------------|
|                         | Healthcare physician | Radiologist | Normal segment | Inflamed segment | Radiologist | Normal segment | Inflamed segment | Radiologist | Normal segment | Inflamed segment | Radiologist | Normal segment | Inflamed segment |
|                         | Normal segment | 36               | 2               | 48             | 3               | 10             | 10              | 42             | 5               | 10             | 15            | 5               | 15             |
|                         | Inflamed segment | 13          | 21              | 10             | 15             | 4             | 5               | 10             | 15             | 4             | 5             | 10             | 15             |

FIGURE 2. Bland-Altman plots for difference in bowel wall thickness between the healthcare physician and radiologists. The difference in BWT per patient (y-axis) is plotted against the mean difference in BWT (x-axis). The mean difference in BWT was 0.25 (SD: 1.53) mm, 0.00 (SD: 0.86) mm, and 0.05 (SD: 1.82) mm for the terminal ileum, transverse colon, and descending colon, respectively. BWT = bowel wall thickness; SD = standard deviation.
measurements in order to eliminate variability inherent to this operator-dependent technique, where subtle IUS differences differentiate normal from inflamed segments, whereas abnormalities are often not homogeneously present within a bowel segment, especially in CD.

There are currently no standardized training guidelines for teaching healthcare physicians in paediatrics how to perform IUS (3). On the basis of our results, performing around 100 dedicated IUS examinations under supervision of both experienced healthcare physicians and radiologists, as part of the International Bowel Ultrasound Group curriculum is sufficient to reach an equal level as an experienced radiologist. Whether this also holds for other types of US, such as screening for appendicitis or intussusception, however, remains to be proven. In addition, the cost-benefit of training health care physicians might be different in centres with smaller IBD populations, where the efforts of following an IUS training and maintaining skills may not balance the benefits.

The strengths of this study are the short time interval between the 2 US examinations and the reference standard, the blinding of all operators, and the central reading procedure for the reference standard. Limitations are the inclusion of 3 different radiologists; although all 3 completed the paediatric radiology training and had > 12 years of experience, the inter-radiologist variability was not assessed and might have biased our results. In addition, we only assessed the diagnostic performance of 1 single healthcare physician, and learning curves may differ individually. More importantly, we used the SES-CD score as reference standard for CD patients, while this score is not validated as segmental score. The cut-off of > 1 value for the segmental SES-CD was chosen by the authors and considered as most appropriate, as this reflects any level of disease activity. Another limitation is the scoring system for the IUS, as to date, there is no consensus on which cut-off value to use when scoring an IUS in children with IBD, both for patients with CD and UC (12). In this study, we pooled results of both IBD entities; however, for studies into optimal use and diagnostic accuracy of IUS, we advise to analyse both entities separately (12). Lastly, as we only used ileo-colonoscopy as reference for this study, we could not assess the small bowel proximal to the TI.

As non-radiologist POCUS is increasingly used in paediatric medicine (3), future research should focus on training of nonradiologists for other purposes as well. Moreover, more research is needed to determine the added clinical value of IUS in the treatment of children with IBD in addition to other frequently used biomarkers of disease activity, such as CRP and faecal calprotectin.

CONCLUSIONS

On the basis of our results, a healthcare physician can be trained to perform IUS in children with IBD with comparable diagnostic accuracy as an experienced radiologist. This supports the uptake of POCUS in the clinical management of children with IBD. Future research should demonstrate the clinical value of IUS in addition to other frequently used biomarkers of disease activity.

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