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Predictors and Ultrasonographic Diagnosis of Intussusception in Children

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1. Introduction

INTUSSUSCEPTION IS THE invagination of a portion of the intestine, called intussusceptum, into the lumen of an adjacent segment of intestine, called intussuscipiens, in the direction of the normal peristalsis or occasionally in a retrograde direction. The intussusceptum is composed of an inner or entering wall and an outer or returning wall.

The first description of intussusception appears in 1793 by Hunter. The first successful operative reduction was reported by Hutchinson in 1873. In 1876, Hirschsprung published the first of several reports on the reduction of intussusception by hydrostatic pressure. Later in 1926, Hipsley described a series of patients managed with this method of treatment.

In human medicine, intussusception is a disease primarily of infants and toddlers, although intussusception can occur at any age; only 10% to 25% of cases occur after 2 years of age.2 The peak incidence occurs between 5 and 9 months,9 and then decline. It rarely occurs younger than 2 months but may occur even in neonatal period. Although rare, intussusception has been reported in preterm infants. Males are affected approximately twice as often as females.

The small intestine is the most difficult part to examine of the gastrointestinal (GI) tract because of its length and tortuous course. The traditional investigations with small bowel enteroclysis and small bowel follow-through reveal information sparingly, and unfortunately involve radiation exposure of the patient. Although it is an organ that is spared from frequent disease, more precise and patient-friendly methods are needed. In the last three decades, new imaging techniques have been developed that have proven useful. Computerized tomography (CT), magnetic resonance imaging (MRI), wireless capsule endoscopy and double-balloon endoscopy are all relatively new additions to the diagnostic armamentarium.

Compared with these methods, transabdominal bowel sonography (TABS), has the advantage of being cheap, portable, flexible and user- and patient-friendly. There are challenges with depth penetration and intestinal air precluding optimal image quality, and the flexibility of ultrasonography (US) warrants a systematic approach by the examiner. However, the development of improved scanner technology and high-resolution transducers has provided the clinician with image data of high temporal and spatial resolution, thus making it a useful tool in the diagnosis of small intestinal diseases. When using US frequencies in the range of 7,5-14 MHz, the wall of the small intestine usually exhibits five different layers that correspond well to the histological layers.

B-mode ultrasonography has been used successfully in the diagnosis of intestinal intussusception in children. The most common sonographic pattern observed in transverse sections of the bowel is a target-like mass consisting of multiple hyperechoic and hypoechoic concentric rings around a hyperechoic center that represents the entrapped mesentery. In longitudinal sections, multiple hyperechoic and hypoechoic parallel lines are usually visible. Exploratory celiotomy followed by manual reduction or resection of the intussuscepted bowel is the usual method of treatment of intestinal intussusception in animals. In children, the primary method of treatment is hydrostatic or pneumatic reduction of the intussusception under radiologic control. However, pneumatic reduction should never be attempted where the bowel is necrotic or perforated.
Prediction of bowel viability and reducibility is of most importance if hydrostatic or pneumatic reduction of gangrenous intussuscepted bowel is to be avoided. A number of ultrasonographic criteria useful in predicting bowel reducibility have been described in children. However, the recognition of blood flow in the intussuscepted bowel using color flow Doppler ultrasonography appears to be the most valuable for predicting bowel reducibility. Radiologically controlled reduction of the intussuscepted bowel is not usually performed to treat intestinal intussusception in small animals. However, ability to predict the reducibility of the intussuscepted bowel could lead to improved prognosis and timing for surgical intervention.
The aim of this review article was to describe ultrasound technic in gastrointestinal examination, US pattern of intussusception and US predictive factors of surgery for intussusception in childrens.

2. Ultrasound of the bowel in children: How we do it

Transabdominal US is currently a well-established method for the evaluation of the small and large bowel [1]. The traditional imaging modalities of the bowel, contrast fluoroscopic studies, are facing competition from or some are being replaced by US of the bowel. Advances in US like high-resolution transducers, harmonic imaging, panoramic modality and contrast-enhanced US have overcome some of the obstacles in bowel sonography that existed in the past. Despite these facts the routine use of US of the small and large bowel in children has significant geographic variations, particularly when looking beyond the evaluation of the appendix. It appears to be more commonly integrated as part of the pediatric bowel imaging work-up in Europe and Canada than in the USA.
A very important application of US of the bowel in children is in the evaluation of inflammatory bowel disease (IBD), particularly Crohn disease. In this group of pediatric patients comparative studies of US of the bowel and ileocolonoscopy and histology have demonstrated the range of sensitivity and specificity to be 74–88% and 78–93%, respectively. It is meant to serve like a recipe and facilitate the routine performance of bowel US in the pediatric age group.

2.1 Step-by-ste approach to performing US of the bowel

A. Patient preparation

US of the bowel can be conducted without any kind of preparation. It is known that significant gaseous distention of the bowel can be an impediment to bowel US.

Lack of even very small amount of fluid in the intestine leads to completely collapsed bowel loops and reduction in peristalsis. The intake of carbonated fluid or very long duration of fasting can lead to such states. Particularly, in such cases the following preparatory step may turn out to be helpful. The oral intake of non-carbonated fluid about 30 min before the US examination may be helpful to reduce the air and also slightly distend the bowel loops. Placing the child in a right lateral decubitus position will hasten the emptying of the fluid from the stomach. A partially filled bladder will assist in the evaluation of the distal sigmoid colon and rectum.

B. Selection of US modalities

The appropriate selection of transducers and modalities will lead to optimal results of the bowel US. After initial trial of various settings a default setting for bowel US needs to be saved for further use. For ease of annotation, where possible, the following labels should also be saved in full or abbreviated: duodenum—DUO, jejunum—JEJ, ileum—IL, terminal ileum—TI, ileocecal valve—ICV, cecum—CEC, ascending colon—AC, hepatic flexure—HF, transverse colon—TC, splenic flexure—SF, descending colon—DC, sigmoid colon—SC, rectum—REC, right upper quadrant— RUQ, right lower quadrant—RLQ, left upper quadrant— LUQ, left lower quadrant—LLQ. Having these annotations allows quick and exact labeling of the image. The body markers are less suitable for exact labeling of the different parts of the bowel. High-frequency, harmonic and panoramic imaging are important US modalities for high-quality imaging of the bowel and can be used in combination or separately.

1. High-frequency imaging: This entails the use of transducers with high frequency. With the advancement of US transducer technology what we regard as high frequency is shifting, too. If 10 years ago a 7.5 MHz transducer was presented as the high-frequency transducer, nowadays many pediatric diagnostic US scanners have transducers that go higher than 15 MHz. It is important to remember the inverse relationship between frequency and penetration depth of the US wave. Thus the right choice of frequency depends on the body habitus of the patient. For practical purposes it is prudent to start with the available highest-frequency transducer for abdominal imaging and switch to lower ones, if sufficient penetration and visualization is not possible. Predominantly linear, but also convex transducers are needed.
2. Harmonic imaging: This is based on the non-linear propagation property of acoustic signal as it travels through the body. Harmonic waves are generated within the tissue and build up with depth to a point of maximal intensity before they decrease due to attenuation. On the contrary, conventional US waves are generated at the surface of the transducer and progressively decrease in intensity as they traverse the body. The harmonic waves are selectively utilized for imaging, eliminating the fundamental frequency. The latter is achieved by highpass filters or through pulse/phase inversion technique, or both. Harmonic frequencies are higher integer multiples of the transmitted frequency. Some US scanners only use the 2nd harmonic for imaging (narrow band), whereas others are capable of implementing a wider range of harmonics (wide band). There is image-quality difference between these two modalities, in general the wide band harmonics modality is of better quality. Harmonic imaging improves axial resolution due to shorter wavelength and lateral resolution through better focusing with higher frequencies. As the harmonic waves are produced beyond the body wall the defocusing effect of the body wall is reduced. The relatively small

amplitude of the harmonic waves results in artifact reduction. In addition, side lobes are less likely to occur and degrade the image. Artifact-free, clear images with higher contrast and spatial resolution are the result. The advantage and superiority of harmonic imaging compared to conventional US for the bowel has been demonstrated in both adults and children.

3. Panoramic imaging: The bowel is a long convoluted structure. The depiction of a longer segment of the bowel by conventional US is limited. To overcome this limitation and to allow documentation of a bowel loop longer the an the length of the transducer one can attempt to use a low-frequency curved-array transducer or dual display mode. These are by far less optimal than panoramic or extended field-of-view imaging. Panoramic imaging involves acquiring multiples of successive US images. With the advanced computational capabilities of US scanners ultrafast motion detection and image processing is possible in realtime. Up to a length of 60 cm can be scanned at one time. It is possible to follow the course of the bowel and make correct length measurements. Moreover, we can use smaller window to evaluate short segments within the scanned bowel.

C. Method of scanning

US of the bowel is conducted with the child in supine position. It is easier for the manual handling if the child is lying closer to the edge of the table nearer to the examiner.

1. Compression techniques: The most important technique to use is graded compression. Non-performance of this maneuver is probably the most frequent reason for suboptimal US images of the bowel. Graded compression is not a technique reserved only for appendix imaging, it is also important for the rest of the bowel. It is prudent in older children to inform them that you are going to compress the abdomen and intermittently look at their facial expression to gauge the pressure exerted. Graded compression displaces disturbing air and adjacent bowel loops, shortens the distance for visualization and isolates the bowel loop of interest. An inflamed bowel is non-compressible in contrast to a normal bowel loop. An additional less known maneuver, but one that we have successfully applied is the adjuvant use of a posterior manual compression technique in combination with the graded compression. The hand not holding the transducer is placed under the back. The back is pushed anteriorly at the same time the graded compression is done in the posterior direction. This technique compounds the effects of the graded compression. It is most useful for depicting the terminal ileum, ileocecal valves and cecum.
2. Scan planes: Each bowel segment is documented in both the transverse and longitudinal planes. Two planes are more important as it allows a better overview of the mesentery.
3. Doppler US: The bowel wall and mesentery do not normally demonstrate significant color signals on power or color Doppler. In contrast an inflamed bowel loop or mesentery can have increased color signals. Thus whenever abnormal bowel wall or mesentery is visualized color or power Doppler examination needs to done. The color Doppler is more commonly used than the power Doppler as it is less sensitive to motion, both from bowel peristalsis and patient movement. The setting of the Doppler has to be very low in order to capture small increase in hyperemia. Color Doppler US is useful for follow-up as it may be the first sign to change prior to significant reduction in bowel wall thickness. Some US scanners have the option of color panoramic modality, too.

4. US clip: The documentation of the presence, absence or relative decrease of peristalsis is done with a short clip. The respective bowel is isolated and the transducer fixed withoutmovement of the hand. An inflamed bowel shows reduced or no peristalsis compared to a normal one.
5. Measurements: If an inflamed loop is detected, two measurements need to be carried out. The bowel wall thickness is measured from the hyperechogenic mucosal to the hyperechogenic serosal interfaces. A 3-mm cut-off for normal bowel wall thickness is generally applicable. Specifically for inflammatory bowel disease in the pediatric age group a thickness for the small and large bowels of greater than 2.5 and 2.9 mm, respectively, are regarded as abnormal [7]. The length of an inflamed bowel segment is best measured using panoramic imaging. Some scanners provide the additional feature of measurement of curved distances.
6. "Itinerary": Using a linear transducer we start with the depiction of the psoas muscle and iliac vessels in the right lower quadrant in the axial plane. From this point it is easy to localize the terminal ileum in its longitudinal plane. We follow the terminal ileum to the ileocecal valves. The ileocecal junction is best viewed at a more obliquely angled view. This is followed by the evaluation of the cecum and ascending colon. These are the bowel loops located most laterally on the right. The transducer is moved along the ascending colon to the hepatic flexure and then turned to the transverse colon. It is important to carefully trace the path of the transverse colon as the stomach and proximal small bowel loops may be easily mistaken for the transverse colon. After that the transducer is moved to the left over the splenic flexure downward tracing the descending colon. This is the bowel loop normally found most laterally on the left. At the distal end of the descending colon the transducer is turned medially to trace the sigmoid colon. The sigmoid colon is depicted in its longitudinal plane over the axial section of the left psoas muscle and iliac vessels. Further tracing of the large bowel to the rectum with a linear transducer may be difficult. Prior to switching to a convex transducer we go on to evaluate the left upper quadrant, the left lower quadrant, the right upper quadrant and right lower quadrants for the duodenum, jejunum and proximal ileum. After a switch to a convex transducer we continue tracing the remaining sigmoid colon and rectum. The latter is best visualized behind a partially full bladder. It is important to remember that at each step the proper selection of US modality is necessary. Furthermore, at each step the use of graded compression, portrayal in axial and longitudinal planes, color Doppler, clips and measurements whenever appropriate is to be stressed. It is also important to document pathological changes of the mesentery around an inflamed bowel loop. Significant gaseous distention of the bowel and adipose body habitus may hinder depiction of all parts of the bowel. The ease of visualization of pathological findings in the different parts of the bowel is also variable, being more difficult in the more proximal small bowel loops than in the distal ones.

There are currently emerging advanced US modalities in bowel sonography. These new applications are starting to be used primarily in adults, but may have potential benefits in children, too. Hydrosonography is a method in which a contrast liquid with low echogenicity is administered orally or rectally for distending the bowel and improving the scan. The specific study for the small bowel is also known under the name small-intestinecontrast- enhanced US or SICUS. An isotonic polyethylene glycol (PEG) solution is commonly used. In Crohn disease hydrosonography of the small bowel was found to be comparable to ileocolonoscopy, wireless capsule endoscopy, and small-bowel sonography in the assessment of the number, site, extension, and postoperative recurrence of small-bowel lesions. In comparison to conventional US the use of oral contrast agent increased the overall sensitivity from 4% to 11%. In particular, it proved advantageous in depiction of proximal small bowel lesions, from 80% to 100%, and in the evaluation of the number and site of small bowel stenoses, increasing the detection by 11–22%. It is important to realize that when we do bowel US without any bowel preparation as described previously that we are doing so with some degree of limitation. Further advanced application includes contrastenhanced US with intravenous administration of US contrast agent for better evaluation of the blood flow to the bowel wall. US elastography or strain imagings are US applications for detecting the elasticity or stiffness of a tissue and providing a visual display. Endoscopic sonography using miniprobes is another new application.

D. Reporting findings

A prepared reporting form or a macro for dictation is helpful to standardize the reporting and provide the referring clinician with clear and consistent sonographic information. Such reporting also makes the follow-up evaluation easier. A sample of a form for reporting has been provided in Table 1. The following sample macro of a normal bowel US finding can serve as the basis for reporting the results and be modified accordingly.

REPORT: ULTRASOUND OF THE BOWEL

BOWEL LOOP:

DUO=Duodenum, JEJ=Jejunum, IL=Ileum [Pro=proximal, Ter=terminal]

CEC=Cecum, ASC=ascending colon, TRA=transverse colon, DES=descending colon, SIG sigma, REC=rectum

*Thickness = if abnormal in mm; *Length = if inflamed bowel length in cm; Extramural findings localized to the closest bowel loop(s)

REPORT:

US of the small and large bowel

HISTORY: Rule out inflammatory bowel disease

COMPARISON: None

TECHNIQUE: US study targeting only the small and large bowel loops. High-resolution US imaging combined with color Doppler.

FINDINGS: An adequate evaluation of the small and large bowel loops could be carried out. The small bowel loops duodenum, jejunum and ileum—were visualized. There was no abnormal wall thickening or pathological color Doppler finding. Specifically, the terminal ileum was depicted and traced to the ileocecal valves. The terminal ileum also has normal bowel thickness and there is no increase in color

Doppler signal. The large bowel loops—cecum, ascending colon, transverse colon, descending colon, sigmoid colon and rectum—were visualized. They did not show any evidence of abnormal wall thickening or pathological color Doppler finding. In addition, the mesenteric echogenicity was normal and there was no mesenteric thickening and hyperemia. There is normal peristalsis. No free fluid is detected.

IMPRESSION: Normal US of the small and large bowel without evidence of inflammatory bowel disease.

Status	Parameter		Bowel loop									
			DUO	JEJ	IL		COLON					
					Pro	Ter	CEC	ASC	TRA	DES	SIG	REC
Not visualized												
Visualized	**Bowel wall**	**Thickness***										
		Echogenicity										
		Stratification										
		Blood flow										
		Peristalisis										
		Ulceration										
		Disruption										
		Phlegmon /Abscess										
		Stenosis										
		Length*										
	Mesentery	**Thickening**										
		Bowel separation										
		Echogenicity										
		Blood flow										
		Fistula										
	Lymph nodes	**Enlargement**										
		Blood flow										
	Abscess											
	Bowel conglo-merate											

Table 1. Standardized form for reporting findings of US of the small and large bowel

2.2 Ultrasonographic findings

High-resolution US can demonstrate the multiple layers of the bowel wall Fig. 1. The innermost hyperechoic line corresponds to the mucosal interface with the lumen. The mucosa itself is hypoechoic and this is followed by the hyperechoic submucosa and hypoechoic muscularis. The outermost layer is hyperechoic and represents an interface echo between the surrounding structures and the serosa. We speak in US of normal stratification of the bowel wall if five layers are visible and of loss of stratification if one or more US layers are missing. The jejunum demonstrates more folds and peristalsis than the ileum. The colon displays even less peristalsis and more air-filling. If the bowel loop contains gas, only the front wall may be visible while the rear wall is concealed by the shadow cone and by the gas generated reverberation artifacts.

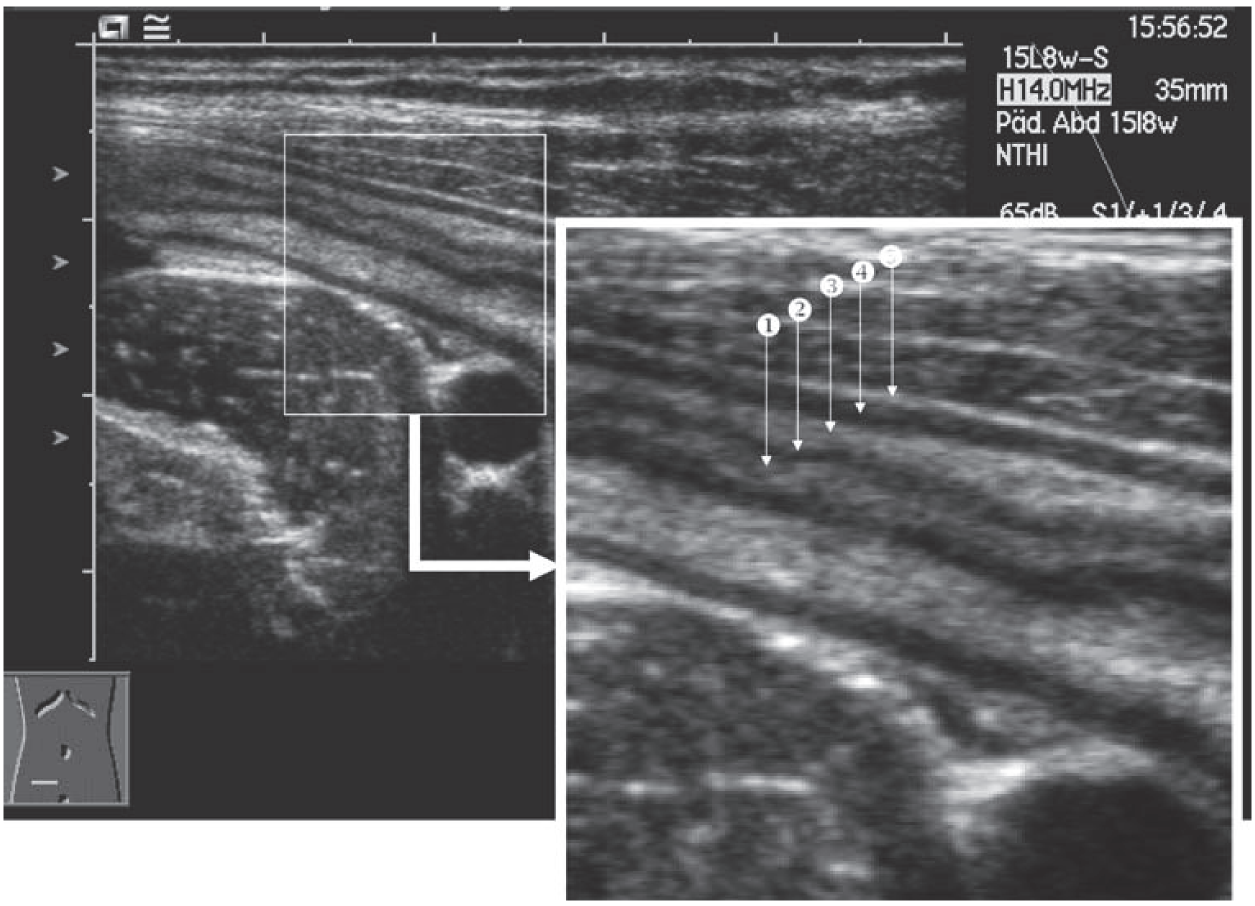

Fig. 1. The terminal ileumscanned with a linear transducer at 14 MHz. All the five layers of the bowel wall are well visualized. A magnified view with labeling of each layer is provided: ❶ HYPERechoic mucosal interface, ❷ HYPOechoic mucosa, ❸ HYPERechoic submucosa, ❹ HYPOechoic muscularis, ❺ HYPERechoic serosal interface

3. Pathophysiology of intestinal intussusception in infants and children

Intussusception is one of the most common causes of acute abdomen in infancy. The condition occurs when a segment of intestine (the intussusceptum) prolapses into a more caudal segment of intestine (the intussuscipiens). This condition usually occurs in children between 5 months to 2 years of age. In this age group most intussusceptions are idiopathic with no pathologic lead point demonstrated. More than 90% of intussusceptions are believed to be secondary to enlarged lymphoid follicles in the terminal ileum.

Intussusception is more common in boys and the condition is rare in children younger than 3 months. The peak incidence is between 5 and 9 months of age. Lead points are noted in children younger than 3 months of age or greater than 2 years of age. Lead points include such entities as Meckel's diverticulum, duplication cysts, intestinal polyps, lymphoma, and intramural hematomas. Transient intussusception is seen in patients with celiac disease (sprue). Most intussusceptions involve the ileocolic region (75%), where the ileum becomes telescoped into the colon. This is followed in decreasing frequency by ileoileocolic, ileoileal, and colocolic intussusceptions. The classic clinical triad of acute abdominal pain (colic), currant jelly stools or hematochezia, and a palpable abdominal mass is present in less than 50% of children with intussusception. Up to 20% of patients may be pain free at presentation. Additionally, in some instances lethargy or convulsion is the predominant sign or symptom. This situation results in consideration of a neurologic disorder rather than intussusception. Given the uncertainty of achieving an accurate clinical diagnosis, imaging is required in most cases to achieve an early and quick diagnosis to reduce morbidity and mortality. Delay may be life threatening because of the development of bowel necrosis and its complications.

3.1 Literature review of intestinal intussusception in infants and children

Much controversy exists in the literature related to the diagnosis and management of intussusception. Realistically speaking children with intussusception can be managed successfully in a number of different ways. It is best to use diagnostic tools that are as benign as possible, however, to avoid potential harm to these children and to lessen the discomfort to the children who are not shown to have intussusception.

The coiled spring sign is produced when the edematous mucosal folds of the returning limb of the intussusception are outlined by contrast material in the lumen of the colon. The enema examination, however, can be a very unpleasant experience for both the parent and child and is also associated with radiation.

The role of sonography in the diagnosis of intussusception is well established with a sensitivity of 98% to 100% and a specificity of 88% to 100%. It has been suggested that sonography should be the initial imaging modality and that the enema examination should only be performed for therapeutic reasons. Sonography not only aids in the diagnosis of intussusception but it also allows the identification of patients who are candidates for therapeutic reduction. Sonography may also detect other abnormalities that are overlooked by the enema examination. In addition, there is a high level of patient comfort and safety with US.

A technique of graded compression is used for the sonographic evaluation of suspected intussusception. Because deep penetration of the US beam is not necessary in small children, a linear high-resolution transducer, 5 to 10 MHz, can be used to improve the definition of the image. The abdomen and the pelvis should be scanned in both longitudinal and transverse planes. The intussusception mass is a large structure, usually greater than 5 cm. Most intussusception occurs in the subhepatic region often displacing adjacent bowel loops. Even inexperienced operators can readily identify the intussusception on sonography. An intussusception is a complex structure.

The intussuscipiens (the receiving loop) contains the folded intussusceptum (the donor loop), which has two components: the entering limb and the returning limb. The attached mesentery is dragged between the entering and returning limbs. Sonographically, the intussusception may demonstrate an outer hypoechoic region surrounding an echogenic center, referred to as a ‘‘target’’ or ‘‘doughnut’’ appearance.

The hypoechoic outer ring seen on axial scans is formed by the everted returning limb, which is the thickest component of the intussusception and the thin intussuscipiens. The echogenic center of intussusception contains the central or entering limb, which is of normal thickness and is eccentrically surrounded by hyperechoic mesentery. Another pattern of imaging that has been described is that of multiple con- centric rings. Within the bowel wall the mucosa and submucosa are echogenic, whereas the muscularis layer is hypoechoic. Multiple hypoechoic and hyperechoic layers are identified when there is little bowel edema present. This represents the mucosa, submucosa, and muscularis layers of the intussusceptum and intussuscipiens. With increasing degrees of bowel edema, the hyperechoic mucosal and submucosal echoes are obliterated in the intussusceptum resulting in fewer layers. On long axis scans the hypoechoic layers on each side of the echogenic center may result in a reniform or pseudokidney appearance. The pseudokidney sign is seen if the intussusception is curved or imaged obliquely.

Although the target and pseudokidney signs are the most common ultrasonographic signs used, they are not pathognomic because they have also been seen in normal or pathologic intestinal loops. Differential consideration for the US findings includes other causes of bowel wall thickening, such as neoplasm, edema, and hematomas. An inexperienced operator may mistake stool or psoas muscle for an intussusception.

In addition to diagnosing the intussusception US has other advantages. US may detect the presence of a lead point, which is present in approximately 5% of intussusception. Various sonographic findings have been reported to be predictive of success of hydrostatic reduction. A study shows that the sonographic presence of enlarged mesenteric lymph node in the intussusception is a prediction of hydrostatic irreducibility. Small amounts of free peritoneal fluid are seen in up to 50% of cases. The presence of trapped peritoneal fluid within an intussusception correlates significantly with ischemia and irreducibility, however, because it reflects vascular compromise of the everted limb. Additionally, the absence of flow within the intussusception on color Doppler sonography correlates with a decreased success of reduction and a higher likelihood of bowel ischemia, and presence of color flow within the intussusception correlates with higher success rate of its reduction.

There are many different techniques used to reduce intussusception described in the literature. Water-soluble contrast material, barium, air enema guided by fluoroscopy, and physiologic saline solution combined with US have all been used. The use of sonography to guide hydrostatic reduction has been predominately performed in the eastern hemisphere and is increasingly being used in Europe. The reduction rate is high (76%– 95%), with only 1 perforation in 825 cases reported. The procedure may be performed with water, saline solution, or Hartmann solution. The instilled fluid is followed as it courses through the large bowel until the intussusception is no longer visualized and the terminal ileum and distal small bowel are filled with fluid or air. There has been little experience with US-guided air enema therapy. Because air prevents the passage of the US beam, it may be difficult to visualize the ileocecal valve; therefore, small residual ileoileal intussusception can be observed. Additionally, it is difficult to detect perforation resulting in pneumoperitoneum. Sonography has been shown to be highly successful in the diagnoses and reduction of intussusception. The appropriate use of US in children with suspected intussusception obviates the necessity for diagnostic enema, and the use of enema should be limited to therapeutic purposes.

In children with intussusception or intestinal invagination, the typical finding on transabdominal bowel sonography (TABS) is a multilayered lesion with concentric circles (onion sign) in the right fossa, when seen in the transversal lane. When the mesentery is involved, this forms an echo-rich crescent open towards the ante-mesenteric side. This is called the crescent in the donut sign. When seen longitudinally, the mesentery is seen as an echo-rich layer between two multilayered structures, the sandwich sign. Using these criteria, a sensitivity of nearly 100% and a specificity around 90% have been found in prospective studies. TABS can also be used as guide in treatment procedures with hydrostatic reduction. Color Doppler examination of children with intussusception shows that absence of flow in the wall of the invaginated intestine makes reduction more difficult, but does not necessarily

mean the intestine is necrotic. In adults, TABS has proven useful as a primary diagnostic method, but since intestinal invagination is a rare cause of bowel obstruction in adults, it is often found by other means. The TABS appearance is similar to that in children, but there is often other pathology present that is the pathological lead point of the invagination.
As a result of the low number of incidents, there have been no prospective studies in the literature. Transient intestinal invaginations occur in children and adults, and mostly without symptoms. If there are no pathological lead points, the discovery is incidental, and if the intestinal segment is shorter than 3.5 cm, they are considered harmless.

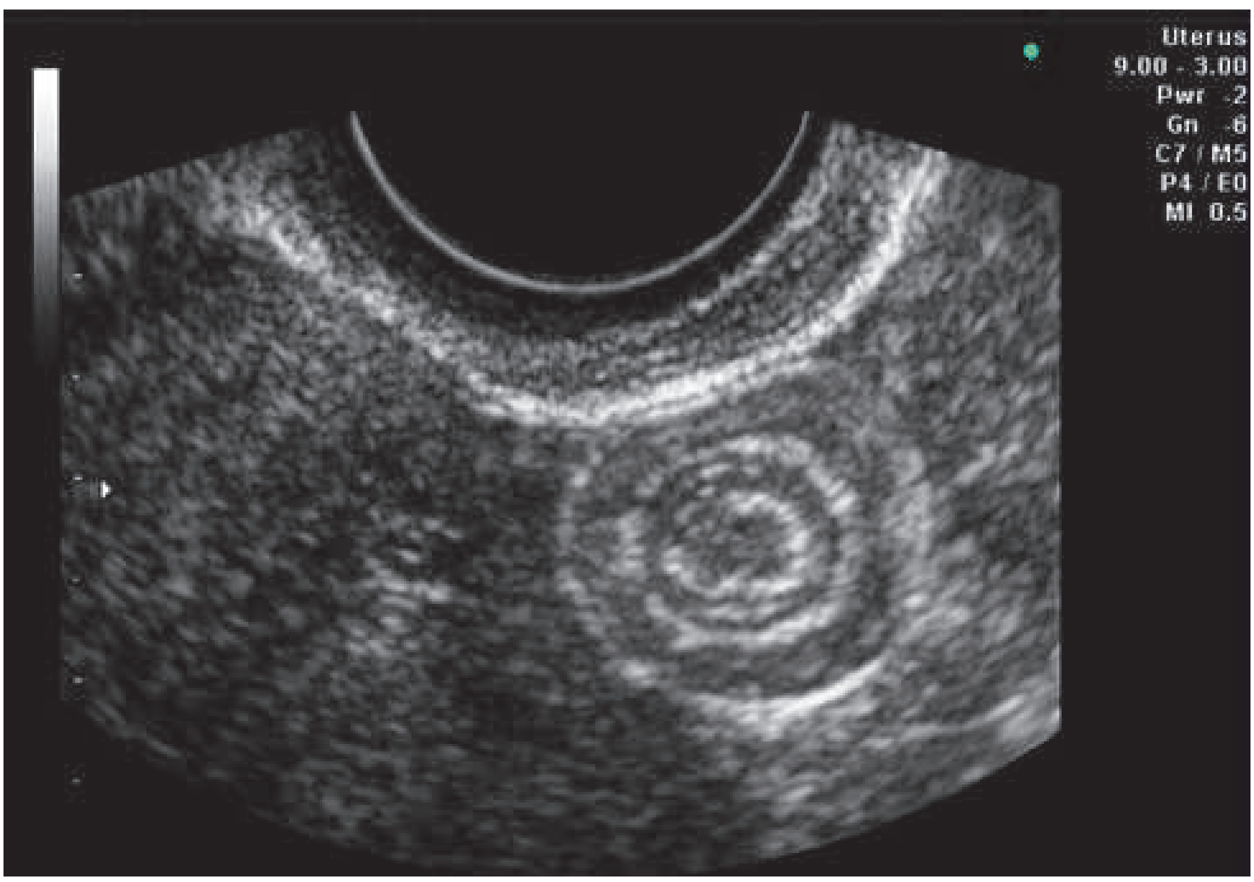

Fig. 2. Target sign noted adjacent to the uterus on a transvaginal scan.

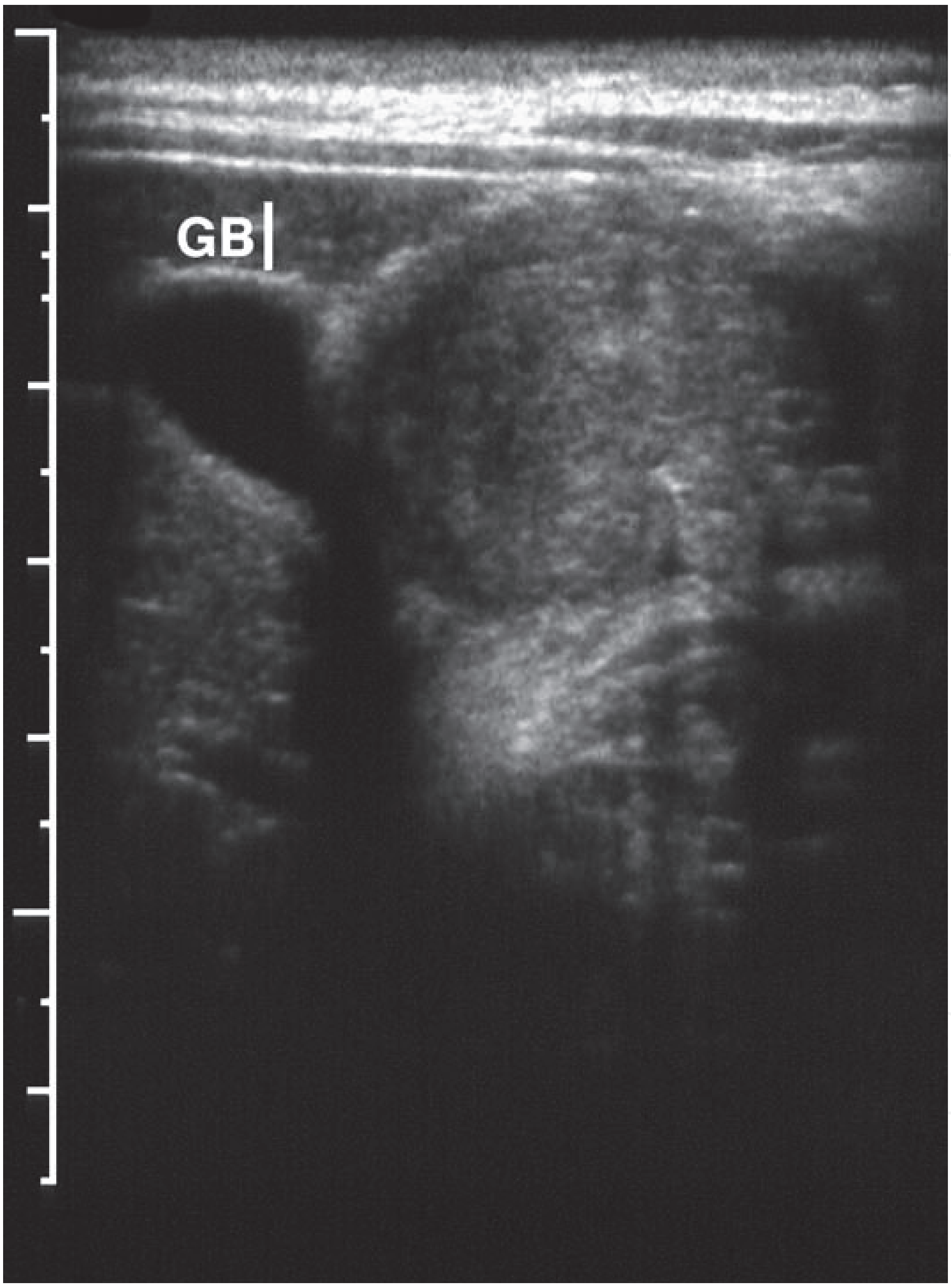

Fig. 3. Intestinal intussusception. Transverse sonographic image demonstrates a soft tissue mass in the right upper quadrant adjacent to the gallbladder (GB)

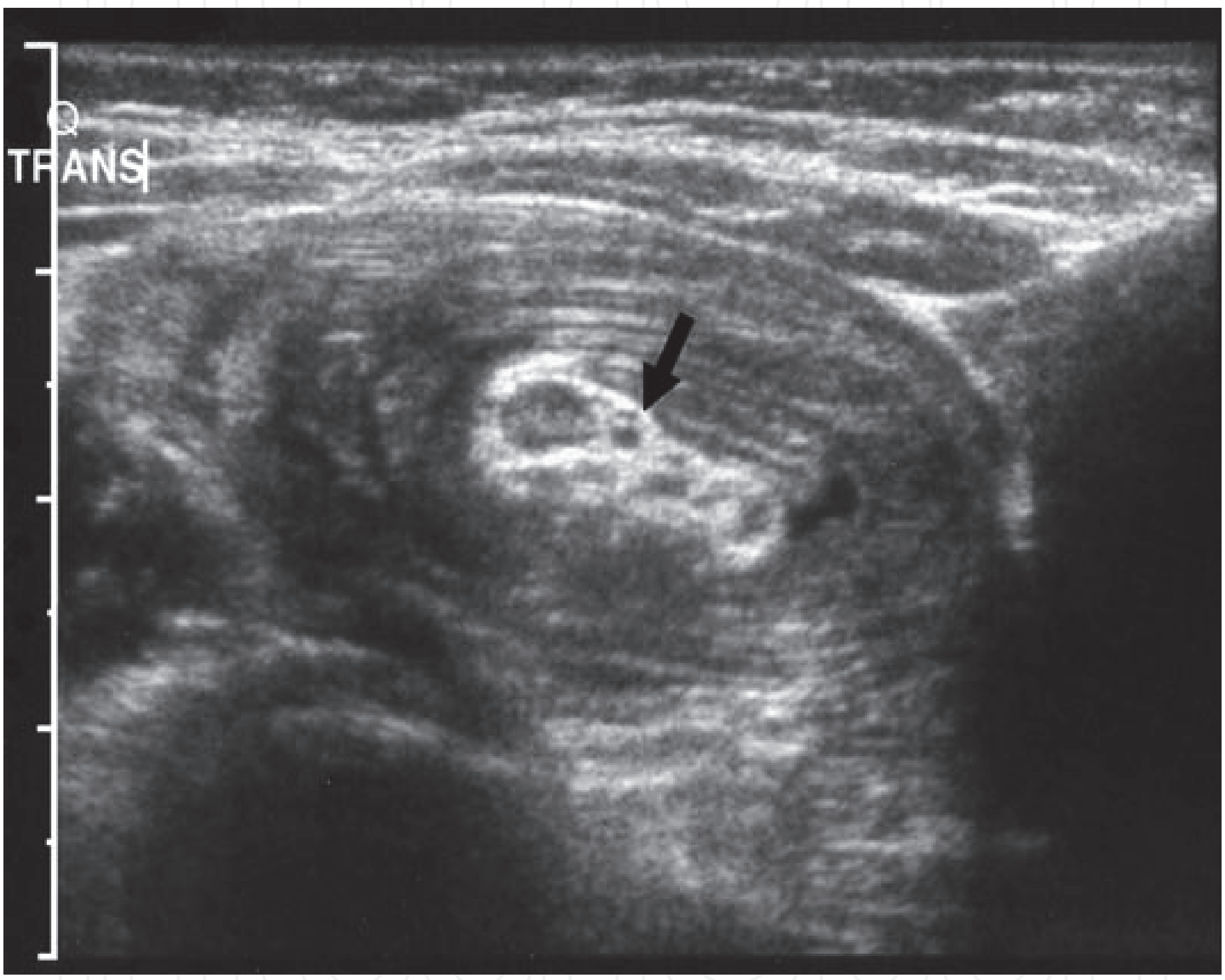

Fig. 4. Target appearance. Transverse sonographic view demonstrates the intussusception. The hypoechoic outer layer represents the intussuscipiens and the central echogenic layer represents the intussusceptum (arrow).

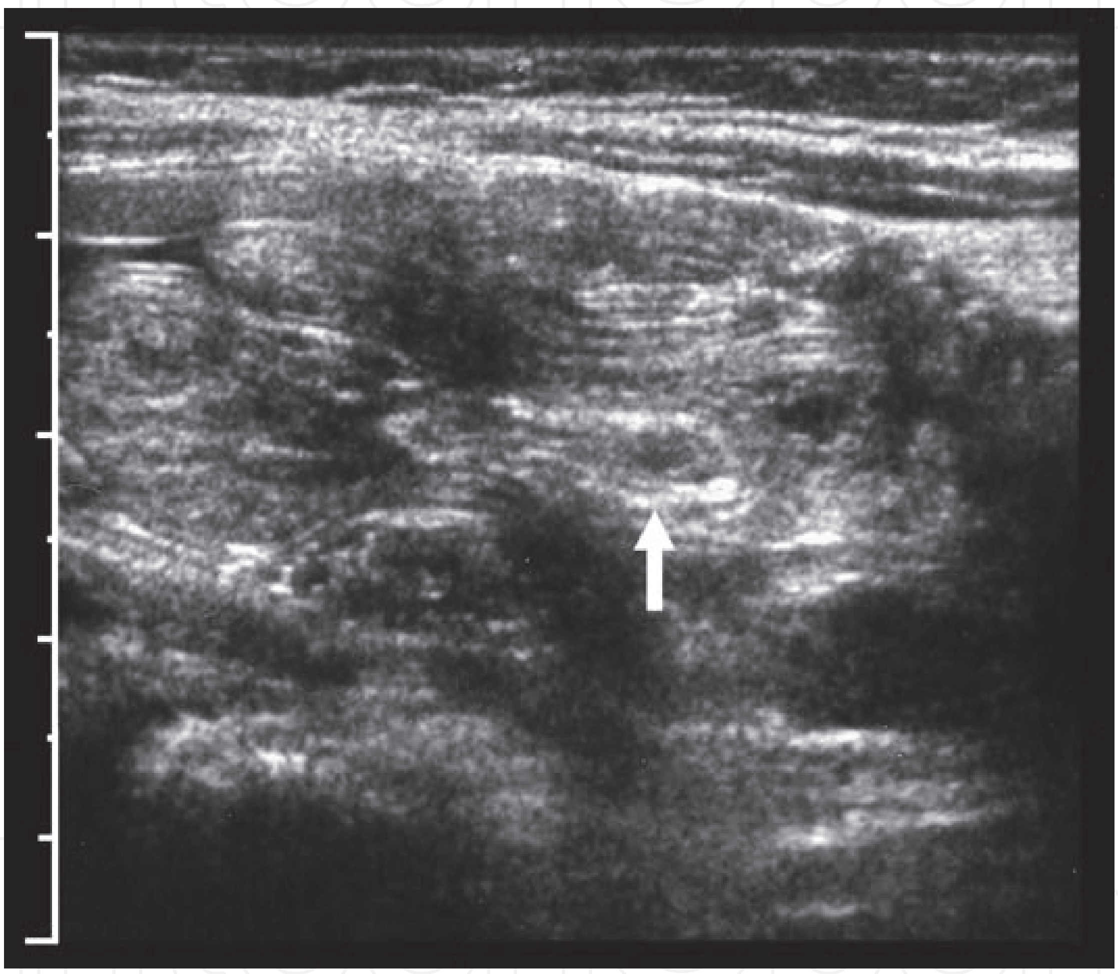

Fig. 5. Long-axis sonographic view shows an elongated appearance resulting in a pseudokidney appearance (arrow).

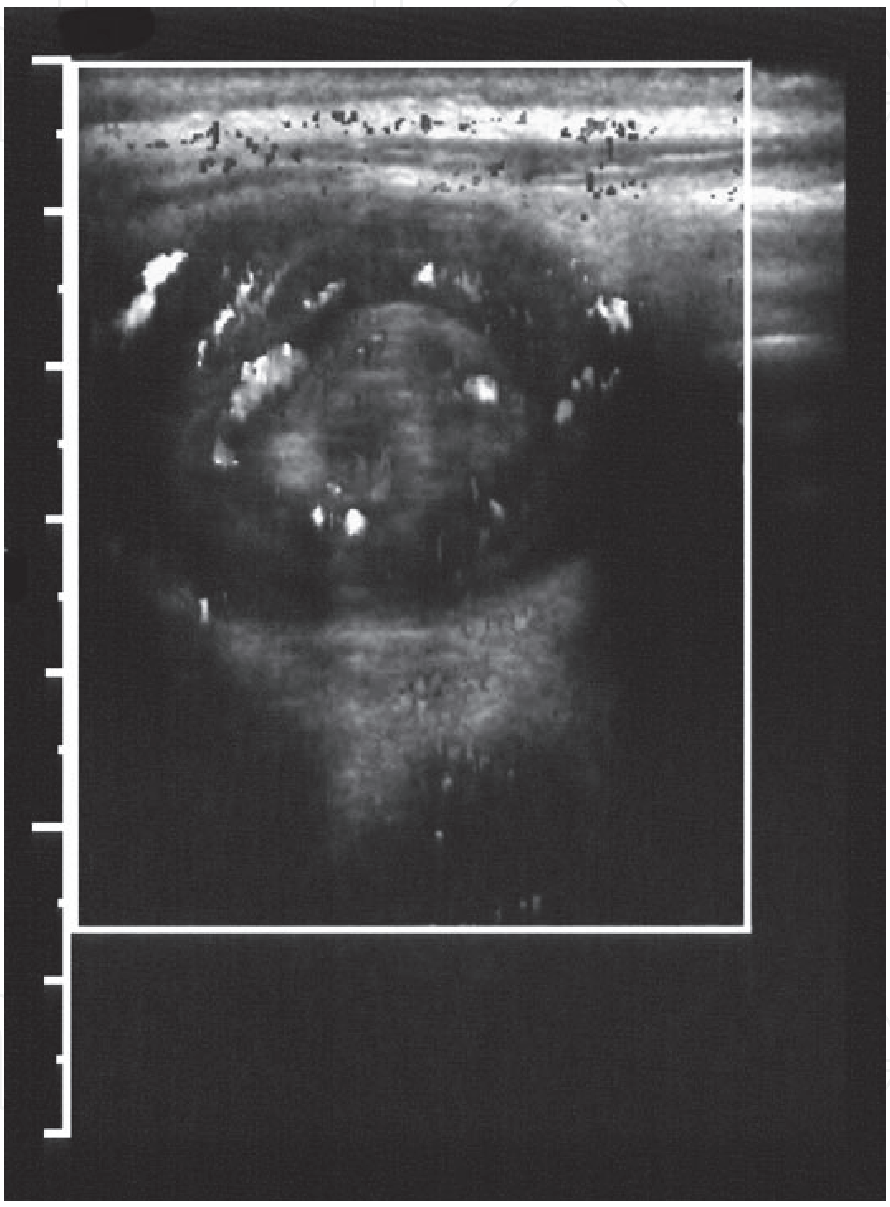

Fig. 6. Use of Doppler ultrasound to evaluate intussusception. Doppler ultrasound shows blood flow within the intussusception, suggesting its reducibility.

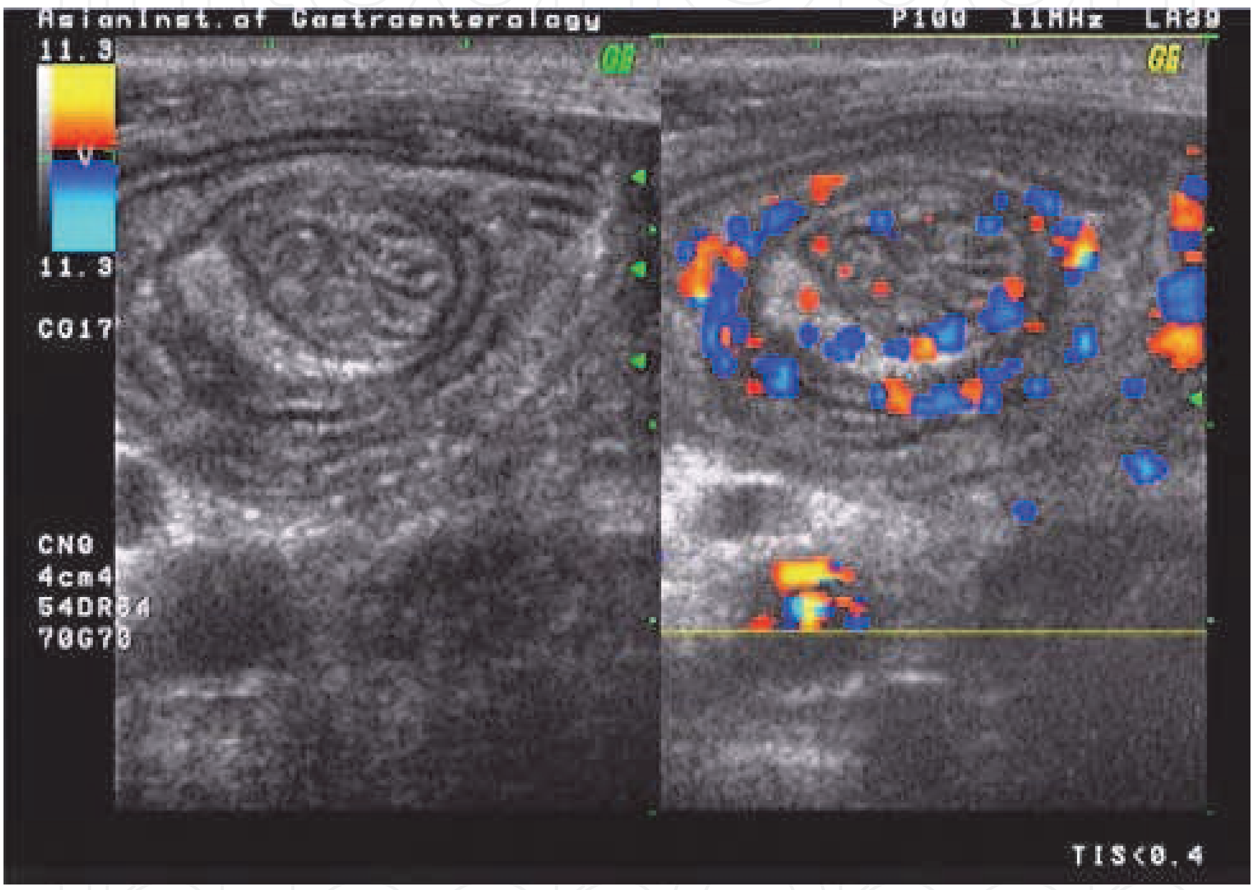

Fig. 7. Color Doppler demonstrating the vascularity of the intussusception.

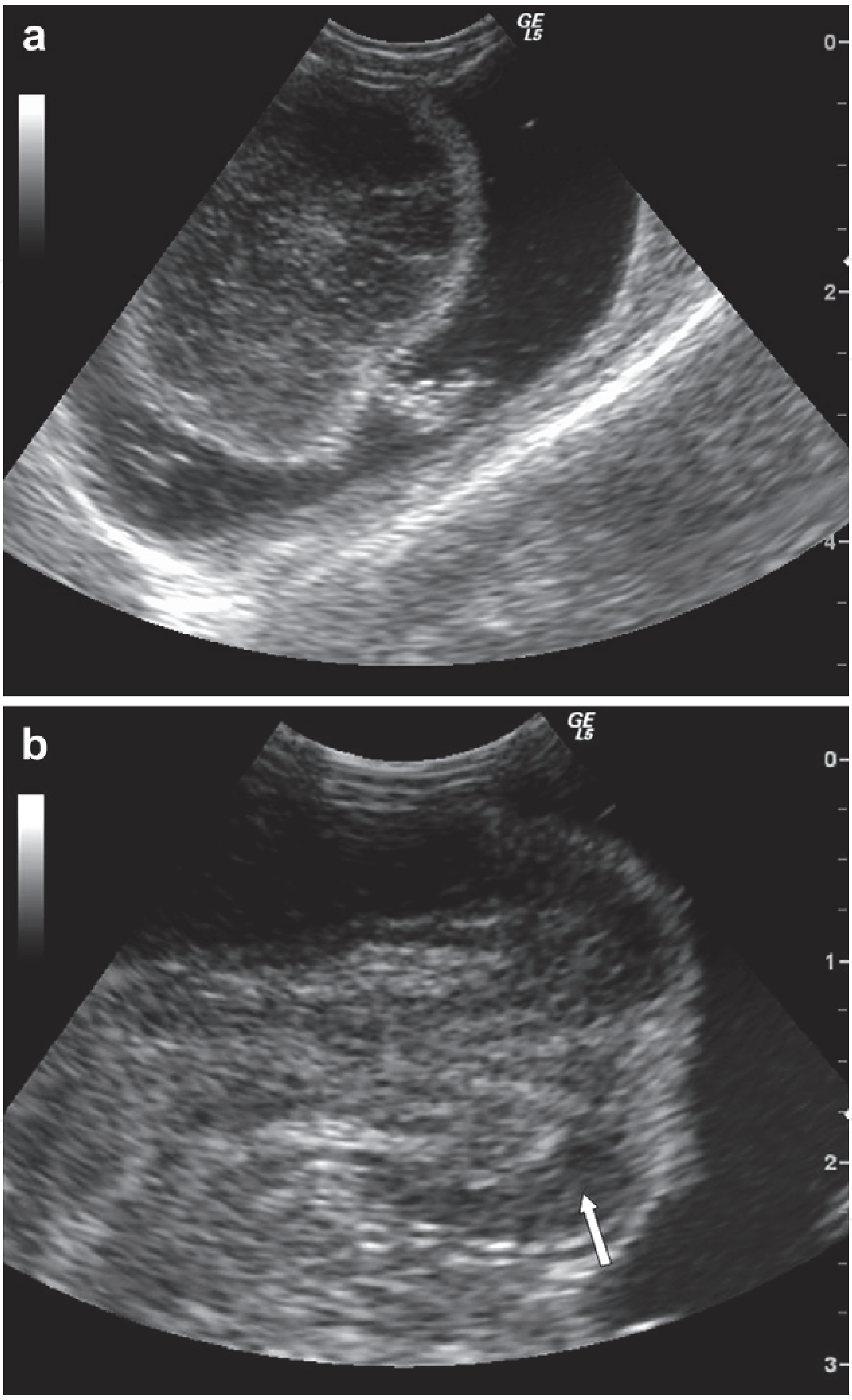

Fig. 8. US examination of the pylorogastric intussusceptions (rare case). (a) Transverse image of the pyloric region. Multiple concentric echogenic and echolucent rings were visible. (b) Longitudinal image of intussusceptions seen in (a); pylorus and proximal duodenum were displaced into the pyloric antrum and fundus; severely hypoechoic gastric mucosal layer caused by edema (arrow).

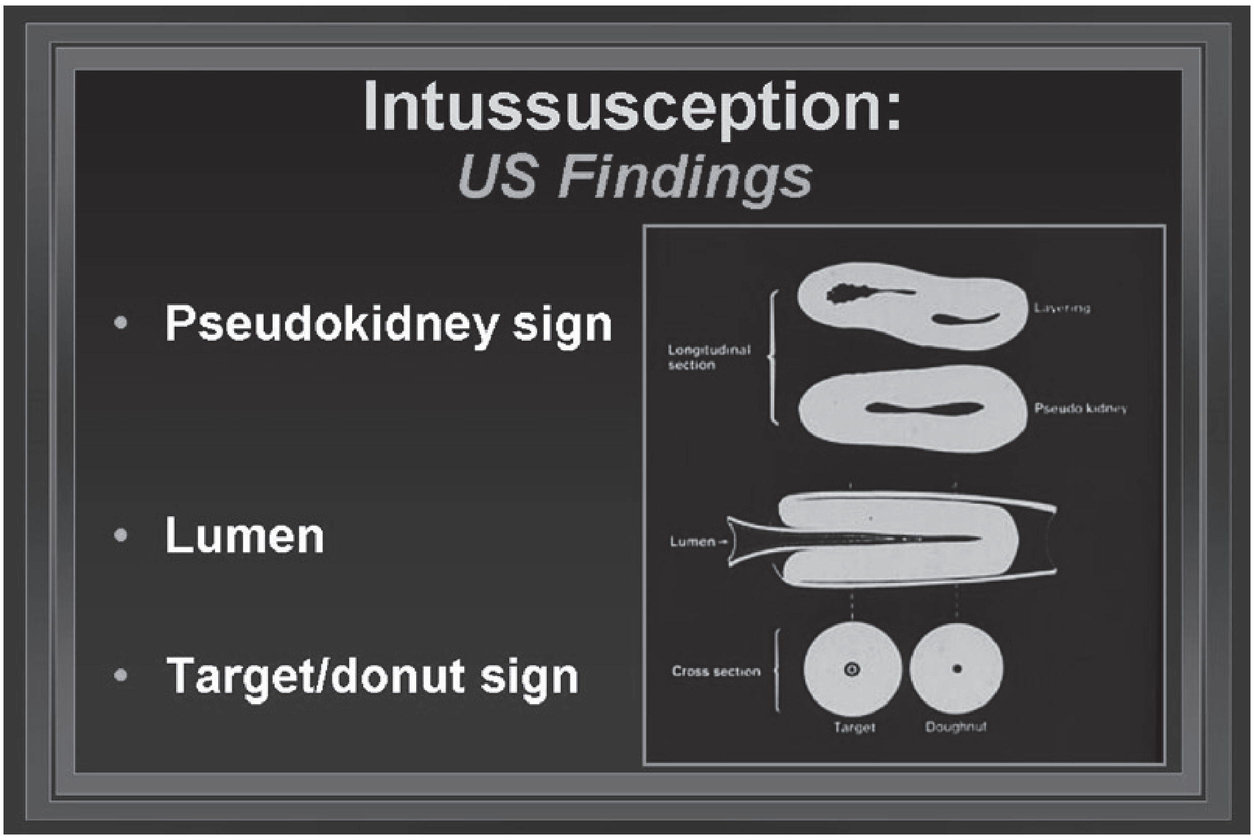

Fig. 9. Various signs of intussusception on cross-sectional imaging. Depending upon the plane through which an intussusception is imaged, various configurations may be demonstrated. On cross section, the head of the walls of the intussusception may appear as a double donut or target sign. The image on the right demonstrates the pseudokidney sign obtained by imaging the intussusception in a longitudinal plane.

4. Discussions and conclusion

Acute intussusception is the most common condition causing an acute abdomen in infants, and typical clinical manifestations include paroxysmal crying, abdominal pain, abdominal mass, and bloody stool. Intussusceptions are usually located in the ileocolic region and ileocecal junction, and these two types comprise approximately 80% of the intussusceptions in pediatric patients. Small bowel intussusceptions (SBIs) are relatively rare and accounts for <10% of the intussusceptions in pediatric patients. Clinical manifestations of SBIs are not typical, patients may present with non-specific signs and symptoms, an abdominal mass and bloody stool occur infrequently, and diagnosis may be delayed resulting in intestinal necrosis and a potential life-threatening situation.

Ultrasound is highly accurate for the diagnosis of ileocolic intussusceptions with a reported sensitivity of 98–100%, and the ultrasound detection rate for SBIs is approximately 76%. Diagnosis of an intussusception is made by the appearance of characteristic findings on ultrasound. Because some SBIs reduce spontaneously, it is controversial whether or not surgical treatment is necessary for all cases in pediatric patients. Doi et al. reported that spontaneous reduction happens in most cases of SBI in children, and only clinical observation, rather than surgical intervention, is needed and has termed these transient intussusceptions, benign SBIs. Sönmez et al consider that SBIs secondary to Henoch–Schonlein purpura can be reduced spontaneously, and conservative treatment is feasible. However, Ko et al. report that persistent SBIs are often associated with intestinal ischemia, necrosis, and perforation, and surgical intervention is warranted once diagnosed. Koh et al. consider that though spontaneous reduction can be achieved in most cases of SBIs, surgical treatment is inevitable in some patients with intestinal ischemia or a pathological lead point.

Therefore, it is clinically very important to determine whether an SBI is likely to reduce spontaneously in order to avoid complications and perform surgery in a timely manner, as well as avoid surgery when not necessary. In the present study, we carried out a retrospective analysis of pediatric patients with SBIs who required surgery and in whom the intussusception resolved spontaneously in order to identify ultrasound characteristics predictive of the need for surgical management. That an intussusception diameter ≥2.1 cm, length ≥4.2 cm, and thickness of the outer rim ≥0.40 cm predict the need for surgical management in pediatric patients with SBIs. These values may be of assistance to clinicians when determining if surgery is required in pediatric patients with SBIs. Values below those determined from these data should be interpreted with caution in patients with signs and symptoms of mechanical ileus or intestinal ischemia.

Incidentally detected, small bowel intussusceptions with no identifiable pathological lead point, normal wall thickness, a length of less than 3.5 cm, normal nondilated proximal bowel and normal vascularity on color Doppler are due to physiological variations in peristalsis. These transient nonobstructive intussusceptions may be incidental findings on US due to minor transient disturbances in bowel motility with no clinical significance as they reduce spontaneously and their presence warrants only conservative (TSBI) is underestimated. If the patients had not been undergoing an US examination at that particular time, these intussusceptions would not have been detected. Nevertheless, we believe that TSBI occur in both adult and pediatric populations. Whatever be the possible etiology, their presence does not warrant intervention.

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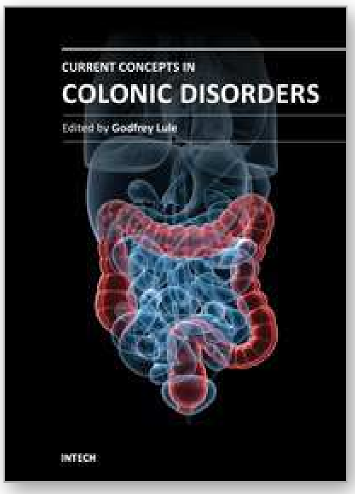

Current Concepts in Colonic Disorders
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The 21st Century has seen a resurgence of research of the gastrointestinal tract, especially since it was established that it plays a central role as an immune system organ and consequentially has a huge impact on causation, impact and transmission of most human ailments. New diseases such as the Acquired Immunodeficiency Syndrome, hepatitis and tumours of the gastrointestinal tract have emerged and they are currently subjects of intensive research and topics of scientific papers published worldwide. Old diseases like diarrhea have become extremely complex to diagnose with new and old pathogens, drugs, tumours and malabsorptive disorders accounting for the confusion. This book has set out algorithms on how to approach such conditions in a systematic way both to reach a diagnosis and to make patient management cheaper and more efficient. "Current Concepts in Colonic Disorders" attempts to put all the new information into proper perspective with emphasis on aetiopathogenesis and providing rational approach to management of various old and new diseases. As the book editor, I have found this first edition extremely interesting and easy to understand. Comments on how to improve the content and manner of presentation for future editions are extremely welcome.