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The presence of trapped fluid on ultrasound as high predictive value for intestinal necrosis in pediatric intussusception

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Abstract

Introduction: Intussusception is a pediatric emergency. If it is not treated immediately, the obstruction process can cause arterial obstruction and leads to intestinal necrosis. Not all patient shows classic syndrome triad. Thus, imaging is needed to make the diagnosis. Ultrasonography is the first choice of imaging in children because it is easy, without radiation and sedation. It has high accuracy for the diagnosis of intussusception. Ultrasonographic features of intussusception including target or doughnut sign and pseudo kidney sign. The presence of trapped fluid in intussusception, correlated with intestinal ischemia and necrosis found in surgery. This research aimed to assess sensitivity, specificity, and accuracy of trapped fluid in ultrasound examination compared with the intra-operative findings reported by surgeons in the form of intestinal necrosis in pediatric patients with intussusception in Saiful Anwar Hospital, Malang.

Material and Methods: This research was observational analytic with a cross-sectional design. It used retrospective data of abdominal ultrasound results and surgical operating reports in 30 patients who were diagnosed with intussusception.

Results: Trapped fluid depiction on ultrasound has a sensitivity of 80%, a specificity of 75%, and an accuracy of 76% with regards to necrotic bowel as compared to intra-operative findings.

Conclusion: Trapped fluid in intussusception is a good predictor of intestinal necrosis in cases of intussusception in children.

Keywords: Trapped fluid; Ultrasound; Intestinal necrosis; Pediatric intussusception

1. Introduction

Intussusception is a pediatric abdominal emergency. It is a common cause of intestinal (bowel) obstruction in children aged 3 months to 3 years [1]. The average annual intussusception incidence in Jewish and Arab children aged less than five years is estimated at 36.1 (95% CI 17.0-76.5) per 100,000 [2].

The most common type of intestinal intussusception is ileocolic. Intussusception occurs when a proximal segment of the intestine (intussusceptum) invaginates into the distal intestine (intussusception), usually antegrade, and causes

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venous congestion and edema of the intestinal wall. If it is not treated immediately, this obstructive process can cause arterial obstruction, intestinal necrosis, and even perforation [1].

Classic clinical trials are such as acute colic abdominal pain, "currant jelly stools" or bowel movements accompanied by blood, and abdominal mass. Many patients did not show the whole triad. 20% of children with intussusception do not experience pain at the time of diagnosis [3], and only 30% -68% of children with clinical suspicion experienced intussusception. Therefore, imaging is usually needed to make a diagnosis [4].

Imaging is very important for diagnosis. If there is a suspicion of intussusception, especially if there are two or more main symptoms, ultrasonography would be helpful as an initial test. In children, ultrasonography has proven to be the first choice of imaging techniques in diagnosing intussusception because it has high accuracy without radiation. It does not require sedation and is inexpensive [5]. The sensitivity of ultrasonography to detect intussusception was 97.9% and the specificity of 97.8%; the positive predictive value of 86.6% and the negative predictive value of 99.7% [6]. If the symptoms are dubious, plain photographs can also be taken, but the sensitivity to detect intussusception is only 45% [7].

Pathognomonic imaging of intussusception on abdominal ultrasonography is the image of a donut or pseudo kidney sign consisting of a hypoechoic outer ring and a hyperechoic middle section [4].

In children with intussusception, trapped fluid can be seen occasionally and it has been reported in 10-20% of cases [8]. The presence of trapped fluid within the intussusception is related to the tendency of failure to reduce the enema and ischemia in the intestine [9]. The trapped fluid is seen as a hypoechoic structure in between the serous surface of the intestine affected by intussusception and some literature stated that the presence of trapped fluid is a very good prediction for intestinal necrosis [10].

Intestinal necrosis is the final stage of several different disease processes. They are characterized by cell death due to reduced blood flow to the gastrointestinal tract [11]. Intraoperatively, the intestinal viability was assessed by the surgeon by palpation, the color of the intestine, motility, and bleeding at the cut end of the intestine [12].

Previously, research by Del Pozo et al in 1996 about the presence of fluid in intussusception on ultrasonographic examination and its association with intestinal ischemia in pediatric patients. Del Pozo et al postulates that the fluid is a trapped peritoneal transudate, due to venous stasis and mesenteric edema; Del Pozo et al concluded that trapped fluid depiction in intussusception could be a predictor of intestinal ischemia with a sensitivity of 100% and specificity of 92% [13]. Until now, in Indonesia, there have been no studies on the sensitivity, specificity, and accuracy of the trapped fluid on ultrasonography as a predictor of intestinal necrosis in cases of intussusception in children.

Based on the background above, this study was done to further determine the sensitivity, specificity, and accuracy of the presence of trapped fluids on ultrasonography as a predictor of intestinal necrosis compared with the gold standard results of surgery in cases of intussusception in children in Indonesia, especially in Saiful Anwar Hospital, Malang.

2. Material and methods

This study was an analytical observational study with a cross-sectional design. Secondary data was taken from the period of January 2017 to July 2019 of 30 patient data, in the Department of Radiology and Pediatric Surgery Section of Dr. Saiful Anwar Hospital, Malang. This study was approved by Ethics and Research Commission Hospital Dr. Saiful Anwar No. 400/155/K.3/302/2019. Data is collected from June to September 2019.

The inclusion criteria of the research consist of pediatric patients who came to the Emergency Department, diagnosed with intussusception by a surgeon, had undergone abdominal ultrasonography by a radiologist with a picture of a doughnut and or pseudo kidney sign, and then the patient underwent surgery. The exclusion criteria include intraoperative diagnosis of non-intussusception or when the ultrasound images were not available for review. The independent variable in this study was abdominal ultrasonography with typical features of intussusception i.e., Doughnut and or pseudo kidney sign, both with or without periluminal fluid, and the dependent variable was the findings of intestinal surgery by the intestinal surgeon. The intraoperative findings were categorized as necrosis/ischemia or healthy.

Based on ultrasonographic image evaluation and combined with operating results data, the sample is divided into four groups.

- Group A: Intussusception patient with presence of trapped fluid on USG and confirmed with necrotic intestine during surgery. N=8
- Group B: Intussusception patient with presence of trapped fluid on USG but no necrotic intestine during surgery. N=5
- Group C: Intussusception patient with absence of trapped fluid USG but there was necrotic intestine during surgery. N=2
- Group D: Intussusception patient with absence of trapped fluid on USG and there was no necrotic intestine during surgery. N=15

3. Results

The research sample consisted of 30 patients' data with sample characteristic in Table below

Table 1 Sample Characteristic based on Gender and Age

Characteristic	Total n (%)
Gender	
Boy	20 (66.7)
Girl	10 (33.3)
Age	
< 3 months	0 (0)
3 months – 3 years	25 (83.3)
> 3 years	5 (16.7)

Table 2 Results of abdominal ultrasound examination and results of surgery in pediatric patients with intussusception

		Surgery Result		Total
		Necrosis	Not Necrosis	
USG Result	Trapped fluid (+)	8	5	13
	Trapped fluid (-)	2	15	17
Total		10	20	30

Based on the table above, it can be calculated sensitivity, specificity, and accuracy of trapped fluid images on abdominal ultrasound examination compared with the gold standard of intestinal viability based on the results of surgery.

Sensitivity = $8 / (8+2) = 80\%$

Specificity = $15 / (5+15) = 75\%$

Accuracy = $15 / (5+15) = 75\%$

Table 3 Degree of Conformity of the Kappa

	Value	Asymp. Std. Error*	Approx. Tb	Approx. Sig.
The measure of Agreement Kappa	0.512	0.157	2.866	0.004
N of Valid Cases	30			

Based on table 3, shows the degree of suitability of Kappa, the Kappa value is 0.512, which means the level of conformity between the results of ultrasound examination and the results of operations is quite good with a significance of 0.004.

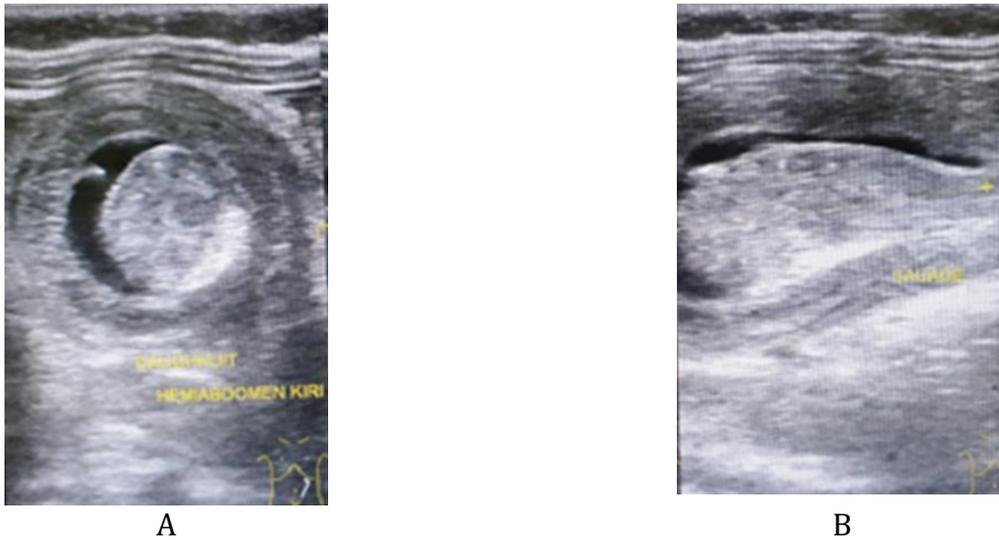


Figure 1 Ultrasound images of intussusception; **A**: (axial image) demonstrates typical dough-nut sign with presence of trapped fluid; **B**: (longitudinal image) demonstrates typical pseudo-kidney sign of intussusception with presence of trapped fluid

4. Discussion

Throughout the process of intussusception, the intussusceptum enters into the distal part of the intestine pulling together with mesenteric blood vessels. Initially, blood vessel compression causes venous congestion and intestinal wall edema. As the obstruction increases, arterial supply is compromised which results in intestinal ischemia, intestinal infarction, even death. More than 90% of intussusception cases are ileocolic intussusception. However, this can also occur in any part of the intestinal segments. Intussusception involving small intestines may also happen and frequently relates to pathological lead point (1,2,14).

Pathogenesis of intussusception in about 90% of cases are idiopathic and estimated to be secondary due lymphoid hyperplasia, which is also or caused by gastrointestinal infections (3,13). Approximately, 5-6% of intussusceptions in children have good pathologic lead points (PLP) because of focal mass or diffuse intestinal wall abnormalities. The most often PLP are (ranked based on the most frequent occurrence): Meckel diverticulum, duplication cyst, polyp, and lymphoma. Diffuse PLP is often related to cystic fibrosis or Henoch-Schonlein purpura. The “classic” medical triad of intussusception consists of acute abdominal colic pain, “red currant jelly stools” (fecal matters accompanied with blood), and abdominal mass or vomiting (14). However, many children experience this triad of symptoms and in certain cases, transient intussusception with spontaneous reduction can occur (7).

The presence of trapped fluids in intussusception cases in literature is an atypical symptom, this is interpreted as the result of an incomplete intestinal collapse. From the intestine’s lumen which experiences intussusception.

There isn’t a critical phase of intussusception. There are 3 components of the intestine that are involved in intussusception, which are two layers of intussusception and 1 layer of intussusception. Intussusception loops in the apex will experience damages, causing progressive edema and transudation through the surface of the intestine formed by the intestine suffering from outward intussusception into the lumen intussusception, if colon then it is more absorbable. On the contrary, transudates leaking out through the serous layer will be trapped between the serous layers and some parts of the intestine will experience intussusception. These fluids cannot flow freely into the peritoneum because of the mesenteric edema, assisting which makes fluid discharge difficult. Next, the transudate will flow from the mesenteric edema to this area. This fluid will illustrate the crescent sign on the axial plane USG. The findings in this study are that on the intestine that is not viable, there are some places of necrosis, when intussusception release is done, and fluids are coming out from the trapped fluid in the form of serous fluid.

On the intestine that is still viable, there are hematoma and edema around the fold and some parts are normal.

In this research, the most cause of intussusception is idiopathic, which subsequently revealed mesenteric gland enlargement.

The presence of trapped fluid in more severe cases, the presence of free intraperitoneal fluid in the ultrasonography does not distinctly portray any perforation and the condition is not able to be reduced in the initial process of the obstruction, therefore stressing the lymph node which builds up pressure on the intestinal walls that experiences intussusception. This leads to venous drainage obstruction.

Up until now, there hasn't been a reliable predictive model based on clinical findings which can accurately identify all patients with intussusception. Due to difficulties in establishing a said diagnosis, imaging becomes crucial to confirm clinical suspicions of intussusception. Patients with clinical suspicion of intussusception must undergo sonography in the case where a competent sonographer is available, and if positive, hydrostatic or pneumatic reduction should be carried out. However, if the patient is in a critical illness condition, a diagnostic sonogram can be beneficial for establishing the diagnosis. Children have to be brought immediately to the operating room for surgery (1).

Based on axial ultrasonography scans, they resemble double-crescent-in-doughnut signs. Aside from the crescent-in-doughnut feature, there is an anechoic crescent which indicated trapped fluid. On a progressed phase, the folded part of the intestine may experience dilatation which is possible due to ischemia and the increasing amount of trapped fluid. Dilatation occurs mainly on the antimesenteric border, which causes asymmetrical fluid distribution. When viewed through ultrasonography, asymmetrically-distributed fluids can resemble dilated bowel loops (for instance, closed-loop obstruction) or duplication cyst. Conversely, only a handful was found with free peritoneal fluid, accounting for 50% of cases. These findings do not always correlate with ischemia or perforation risk increase. Probably need to put a reference here (4).

Preceding research displayed strong relationships between the existences of fluids within the intussusception with intestinal damage.

It was found that out of the three intussusception components (intussusciens and the two intussusceptum limbs), the intussusceptum returning limb (especially the apex of intussusceptum) is the most vulnerable to vascular damages (1).

Venous stasis causes edema and progressive transudation in the entire surface of the intussusceptum returning limb. Because this segment moves, the transudate in every mucosal surface directly flows to the colon lumen and will be easily eliminated (1).

On the contrary, the transudate which exits from its serous layer will still be present and trapped between the two layers of the intussusceptum serous limb. This fluid may not flow freely into the peritoneum because the edematous mesentery acts as a blockage, which makes the exit path through the intussusception neck difficult. Then, the transudate can flow from the edematous mesentery to this space (7).

This fluid provides the feature in the shape of a crescent on the axial ultrasonography scan. The feature adjusts the crescent-shaped cavities left by the mesentery that only attach to one loop side. On progressed condition, likely due to ischemia and the increasing amount of trapped fluid, the apex of intussusceptum widens and grew thinner, resulting in the shape of pyriform, the cul-de-sac feature in the ultrasonography image. Dilatations occurring at the base of the antimesenteric border can explain the presence of an asymmetrical curve on the apex (13).

The result of the research showed that according to gender, it was found that there were more men patients (66.67%) compared to women (33.33%) Is there a p-value to determine whether it is statistically significant or not. This was consistent with previous research. Men are twice as often affected as women [1]. Whereas based on the age of the patient, the greatest number of patients was in the age range of 3 months to 3 years of 83.33%. This was consistent with previous research which states that intussusception rarely occurred at under 2 months of age and above 3 years [1]. From the data obtained, in all research subjects, intussusception occurred was an ileocolic type. This was consistent with the literature which stated that the most common type of invagination was ileocolica [1].

In children with intussusception, trapped fluid between the intussusceptum lumen on ultrasound examination had been reported in 10-20% of cases. Del Pozo et al. first reported that the presence of trapped fluid correlated with intestinal necrosis. It was a peritoneal transudate trapped secondary to venous stasis and mesenteric edema [4.]In this research, it was conducted tests of sensitivity, specificity, and accuracy of the results of ultrasound examination in the form of trapped fluid in the intussusception (Figure 1), compared with the gold standard data report on the results of operations by surgeons in the form of intestinal necrosis in pediatric patients with intussusception.

From the analysis of the data, it was obtained that the sensitivity of the presence of trapped fluid in predicting bowel necrosis was 80%, while the specificity of the presence of trapped fluid, was 75%. It was obtained an accuracy of 76%,

which means the ability of trapped fluid on ultrasonography to correctly detect all subjects tested was 76%. When compared with a study by Del Pozo in 1996, the sensitivity of trapped fluid as a predictor of intestinal necrosis was 100%, while the specificity was 92%. This might be due to the smaller number of samples in this study.

The result of our study showed that the presence of trapped fluid on abdominal ultrasonography examination was quite effective as a predictor of intestinal necrosis in cases of intussusception in children, with 80% sensitivity, 75% specificity, and 76% accuracy.

5. Conclusion

The presence of trapped fluid on ultrasonography compared to intra-operative intestinal necrosis in pediatric patients with intussusception resulted in a sensitivity of 80%, a specificity of 75%, and an accuracy of 76%.

The presence of trapped fluid on abdominal ultrasonography can be considered as a predictor of intestinal necrosis in cases of intussusception in children. It can assist pediatric surgeons in determining the choice of therapy to be taken as well as in the assessment of disease prognosis.

This research has limitations because of the small number of samples, and we did not evaluate clinical risk factors which can be predictors of intestinal necrosis, such as the long duration of the onset of symptoms of the disease to surgery, rectal bleeding, and dehydration. Therefore, it is necessary to carry further research with a larger sample and evaluate other risk factors which influence the incidence of intestinal necrosis in cases of intussusception in children.

Compliance with ethical standards

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Disclosure of conflict of interest

This study has not been duplicate publication and the authors declare that they have no conflict of interest to the publication of this article.

Statement of informed consent

This study was approved by Ethics and Research Commission Hospital Dr. Saiful Anwar No. 400/155/K.3/302/2019

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