

Prediction of Ultrasound Guided Hydroreduction In Pediatric Intussusception Using Clinical Prediction Score

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Abstract

Context: Intussusception is a common disorder of children. The current treatment modality is non operative procedure either by pneumatic reduction or saline hydroreduction. The failure of hydroreduction is one of the disadvantages of non operative reduction. Clinical prediction score (CPS) has been designed by Khorana to predict the success or failure of non operative reduction.

Aims: The present study aims to identify the risk factors for the success or failure of saline hydroreduction.

Settings and Design: This is a prospective observational study conducted in a University Hospital in Kathmandu, Nepal.

Methods and Material: All children with intussusception were subjected to hydroreduction unless contraindicated. The outcome of hydroreduction was measured as 'Successful' or 'Unsuccessful' after the procedure. Clinical characteristics, ultrasound findings, and investigation results were compared between 'Successful' and 'Unsuccessful' groups. The accuracy of CPS for prediction of success was calculated.

Results: A total of 54 children underwent hydroreduction, among whom 47 (87%) were successful while 7 (13%) were unsuccessful. No

patients developed complications. Rectal bleeding, fever and abdominal distension were significantly different between successful and unsuccessful groups. CPS was found to have a significant prediction of outcome for saline hydroreduction ($P < .001$). At a cut-off score of 11, sensitivity, specificity, positive predictive value, negative predictive value were 96%, 86%, 98% and 75% respectively.

Conclusions: Rectal bleeding, fever and abdominal distension were independent risk factors for the failure of hydroreduction. CPS was a good predictor of the outcome of saline hydroreduction.

Key Messages: Hydroreduction is a standard procedure for pediatric intussusceptions. Failure of reduction is a major concern of the procedure. This study focuses different parameters for outcome of hydroreduction. Rectal bleeding, fever and abdominal distension were found as significant predictor of failure of hydroreduction.

Keywords: Intussusception; Hydroreduction; Risk factors; Clinical Prediction Score.

Introduction

Intussusception is the most frequent cause of bowel obstruction in infants and toddlers.¹ It can be seen in all ages of children but 90% of cases occur within three years of life.¹ Current modalities of treatment are non-operative and operative procedures. Pneumatic reduction, barium enema reduction, and saline hydroreduction (HR) are common non-operative procedures. Reduction of intussusception is monitored by fluoroscopy in

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pneumatic and barium enema while ultrasound is used to monitor saline HR. Saline HR is the procedure of choice at our institute because it can be done easily without any specialized instruments and does not expose the child to radiation. Failure of HR is one of the disadvantages of this procedure. Predictive factors of successful HR are not uniformly found in literature.²⁻⁴ In 2016, Khorana et al formulated a clinical prediction score (CPS) for prediction of non surgical reduction of intussusception.⁵ This includes ten variables of clinical characteristics, ultrasound findings and method of reduction with a minimum score of zero and a maximum of 16 (Table 1). A score >11 is associated with failed HR. In this study, we aimed to analyze different clinical characteristics and investigations and used CPS suggested by Khorana to predict the outcome of ultrasound-guided HR.

Table 1: Components of clinical prediction score.

Characteristics	Score
Weight	
≤ 12 Kg	2
> 12 Kg	0
Duration of symptoms	
≤ 48 Hours	0
> 48 Hours	1
Vomiting	
Yes	2
No	0
Rectal bleeding	
Yes	2
No	0
Abdominal distension	
Yes	2
No	0
Temperature ≥ 37.8	
Yes	2
No	0
Palpable mass	
Yes	1
No	0
Location	
Left	2
Right	0
Poor prognostic sign in ultrasound	
Yes	1
No	0
Method of reduction	
Hydrostatic	1
Pneumatic	0

Subjects and Methods

This was a prospective observational study in the pediatric surgery unit of Tribhuvan University Teaching Hospital, Institute of Medicine, Kathmandu, Nepal from July 2017 to September 2018. All children with intussusception who were suitable for HR were included in this study. Study variables were those characteristics included in CPS. The study was approved by the 'Institutional Review Board' of 'Institute of Medicine'. Informed consent was taken from the legal guardian of the child.

Management protocol

The diagnosis was confirmed by ultrasound in a child with clinical suspicion of intussusception in the pediatric emergency room. All patients were considered as suitable unless there was an absolute contraindication. Contraindications were peritonitis, bowel perforation and suspected bowel gangrene.

Procedure

The procedure was performed in the radiology procedure room without anaesthesia. The child was kept in the supine position and a Foley catheter no 18 was inserted in the rectum and the balloon was inflated. The other end of Foley catheter was connected to an enema cylinder containing one litre of warm normal saline kept at 100 cm high. Saline was infused into the rectum by gravity. The flow of saline into the colon and retrograde influx of saline into the ileum through ileocaecal valve was monitored by real-time ultrasound. The reduction technique consists of one to three attempts. Each attempt consisted of a maximum of three minutes of hydrostatic pressure. The procedure was repeated after three minutes if reduction was not achieved in the first attempt. Successful reduction was defined as the disappearance of the target appearance and visualization of fluid reflux into the distal ileum from the caecum through the ileocaecal valve. Failure of reduction even after three attempts was considered as 'Unsuccessful HR' and the child was taken for operative reduction. The procedure was abandoned if any complication occurred or the child could not tolerate the procedure.

Analysis

The outcome of HR was measured as 'Successful' or 'Unsuccessful'. Study variables between 'Successful' and 'Unsuccessful' groups were compared using SPSS version 20. Individual variables were compared using chi-square and

student t-test. Multivariate analysis was done for the significant variables produced in univariate analysis. CPS was compared between the groups using 11 as cut-off value. Receiving operating characteristics (ROC) curve was obtained to check for the best cut-off label in our study.

Results

During the study period, a total of 60 children presented with intussusception. Six children were excluded because one had peritonitis and five had spontaneous reduction of intussusception. Thus, a total of 54 children underwent hydroreduction out of which 47 (87%) procedures were successful and seven (13%) procedures were unsuccessful. Among successful patients, six had early recurrence within hospital stay and were successfully treated on repeat procedure. No patients developed complications.

The youngest patient was three months and the oldest was 70 months. A 68% of children were below two years of age. Other demographic characteristics of patients are shown in Table 2.

Table 2: Demographics of patients (n=54).

Characteristics	Value
Age (Months)	20.5 ± 16.6
Sex (Male: Female)	2.2 : 1
Weight (Kg)	10.2 ± 2.8
Duration of symptoms (Hours)	44 ± 34.3
Symptoms	
Inconsolable cry	48 (89%)
Vomiting	39 (72.2%)
Abdominal distension	8 (14.8%)
Fever	17 (31.5%)
Rectal bleeding	13 (24.1%)
Palpable mass	35 (64.8%)
Right	30
Left	5
Ultrasound findings	
Fluid trapped within the intussusception	5 (%)
Enlarged lymph node in intussusception	21 (%)
Hemoglobin (gm/dL)	11.6 ± 1.1
Total Leukocyte Count (/mm ³)	11200 ± 3040

Data are presented as mean ± standard deviation or number (%) unless specified.

The individual clinical and ultrasound components of CPS were compared between successful and unsuccessful groups as shown in Table 3. Khorana et al had mentioned the method of reduction (pneumoreduction or hydroreduction) as one of the characteristics in his their prediction rule. We performed hydroreduction only in our

study and gave the score accordingly.

Table 3: Univariate analysis of variables with success and failure of hydroreduction.

Characteristics	Successful n (%)	Unsuccessful n (%)	P-value
Weight ≤12 kg (n=46)	40 (87%)	6 (13%)	0.96
Vomiting (yes) (n=39)	32 (82.1%)	7 (17.9%)	0.171
Rectal bleeding (yes) (n=13)	8 (61.5%)	5 (38.5%)	0.006
Duration ≥48 hrs (n=24)	19 (79.2%)	5 (20.8%)	0.221
Temperature ≥37.8 (n=17)	11 (64.7%)	6 (35.3%)	0.003
Abdominal distension (yes)(n=8)	4 (50%)	4 (50%)	0.006
Palpable mass (n=35)	29 (82.9%)	6 (17.1%)	0.4
Left sided mass (n=5)	4 (80%)	1 (20%)	1
Poor signs in USG (n=26)	15 (57.7%)	11 (42.3%)	0.699

Weight, duration and temperature were analyzed as binary variables as described in original CPS.

Age, sex, excessive cry, hemoglobin (Hb) and total leucocytes count (TLC) were other study characteristics in the study. Age, sex, excessive cry were not significant. Hb and TLC were significant in univariate analysis but failed to show significance in multivariate analysis. Rectal bleed, fever and abdominal distension were found to be statistically significant in both univariate and multivariate analysis (Table 4).

Table 4: Multivariate analysis.

Variables	P value (multivariate)	Odds Ratio
Rectal Bleeding	0.04	20
Temperature >37.8	0.03	25
Abdominal Distension	0.05	24
Hemoglobin	0.5	
TLC	0.3	

Table 5: Relation between CPS and outcome.

CPS	Successful (n=47)	Unsuccessful (n=7)	P value
≤11	45	1	<0.0001
>11	2	6	

The overall CPS ranged from three to 14. The mean score in the successful group was 6.6±2.2 and 11.4±2.7 in the unsuccessful group (P < 0.001). Taking cut-off value of score ≤11 as successful and

the score >11 as unsuccessful hydroreduction, the difference was significant (Table 5). At cut-off label of score 11, sensitivity, specificity, positive predictive value and negative predictive value were 96%, 86%, 98% and 75% respectively. We tried to calculate whether a different cut-off value exists. ROC curve was plotted to different scores. The area under the curve was 0.903 (standard error: 0.079, confidence interval at 95%=0.747-1.000) (Fig 1). The optimum cut-off was found at a score of 11.

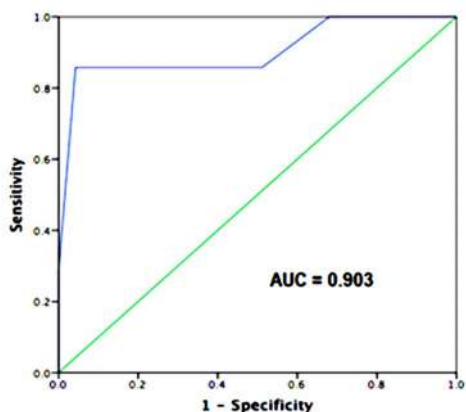


Fig. 1: Receiving operative characteristics of clinical prediction rule for predicting success of hydroreduction.

Discussion

The treatment of pediatric intussusception has changed from operative to non operative reduction over time. Since most of the intussusception is of ileocolic type, it is feasible to reduce by air or water enema. Ever since Kim et al¹⁶ reported the first successful hydroreduction in 1982, it has gained popularity worldwide. Currently, fluoroscopy-guided pneumoreduction or ultrasound-guided hydroreduction is the treatment of choice.⁷⁻¹⁰

For the last one decade at our institute, we practice ultrasound-guided HR as the first line of treatment for pediatric intussusception unless contraindicated. The safety of HR is well established. The complications of HR are intestinal perforation, fluid overload, vomiting and aspiration during the procedure but the incidence is quite low.^{8,11-13} Perforation occurs in preexisting gangrenous bowel.^{14,15} Even if HR fails in the first attempt, delayed repeated enema may result in a successful outcome without apparently increasing morbidity.¹⁶ Fortunately, we did not encounter any complications in the current series of patients. Barium enema reduction used to be a good method of reduction. However, this has a risk of radiation and severe chemical peritonitis occurs if bowel

perforates. We find less recent studies regarding barium enema reduction.

The biggest issue of ultrasound-guided HR is the failure of reduction. The success rate of HR varies from 70-96% in the literature.^{6,8,17,18} The probable reasons for this varied success rate are failure to choose appropriate patients and ignoring risk factors for failure. The present study showed a success rate of 87%. The risk factors for success or failure are also varied in literature. Duration of symptoms, rectal bleeding, and abdominal distension are important in many studies. Age, weight and vomiting are significant only in a few studies.

Duration of symptoms is a significant factor associated with the failure of hydroreduction as identified in various studies.^{2,4,19} In our study, the mean duration of presentation to the hospital was 49±27 hours in the success group and 84±58 hours in the failure group (P<.01). However, with regards to success and failure in patients presenting before 48 hours and after 48 hours, the duration was not statistically significant.

Khorana et al had concluded weight to be a risk factor stating small caliber of the intestine in low-weight infants to be a risk factor.²⁰ Avci et al and Khirallah et al failed to find association of weight and successful reduction.^{2,3} Our study doesn't find the association between weight and failure of hydroreduction.

Studies by Khirallah et al, Fallon et al and Khorana et al have shown that age <1 year is significantly associated with failed reduction.^{2,19,20} However, with increasing age of the child, there is a higher chance of the presence of pathologic lead point and thus the groups may not be comparable. Age is not a risk factor in other many studies.^{3,4}

Rectal bleeding is a classic symptom of intussusception and was found to be significantly associated with failed reduction by He et al and Karadager et al.^{21,22} Our study also found rectal bleeding to be an independent predictor of failure of hydroreduction. Rectal bleeding indicates that bowel ischemia has set in and has resulted in mucosal sloughing, and this may necessitate early intervention. However, this is not a contraindication for nonsurgical reduction. Avci et al failed to show rectal bleeding as a risk factor.³

Fever has been considered a risk factor for surgical intervention by Fike et al and Khorana et al.^{4,20} Fever may be due to systemic inflammatory response triggered by intra-abdominal inflammation. Our study also found fever (temperature >37.8 C) to be

a significant risk factor for predicting the outcome of hydroreduction. Fever can be a manifestation of bowel ischemia. The need for intestinal resection significantly increases with fever.¹⁹

Presence of free intraperitoneal fluid, thick peripheral hypoechoic rim suggesting increased bowel edema, fluid trapped within the intussusceptum, enlarged lymph node within the intussusception, pathologic lead point and absence of blood flow in the bowel were considered as poor prognostic signs in the ultrasound.^{2,20,21} This study failed to find these factors as poor prognostic factors. Similarly, Gartner et al also showed that the presence of free fluid had no impact on the rate of success of intussusception reduction.²³

In the effort to make uniformity of these risk factors, some authors have suggested a scoring system for the management of intussusception. In 1986, Guo et al had devised a tool to predict the success of air reduction.²⁴ Rege modified Guo's scoring system and proposed a similar scoring system in 1991.²⁵ Weihmiller et al set up a decision tree to diagnose intussusception in 2011. This criterion however didn't include a scoring tool.²⁶ In 2016, Khorana et al formulated clinical prediction rules for failed nonoperative reduction of intussusception.⁵ This prediction scores ranged from 0 to 16. A high-risk group (scores 12-16) predicted greater chance of reduction failure while a low-risk group (scores 0-11) predicted a lower chance of reduction failure. Sensitivity, specificity, positive predictive value and negative predictive value were 98%, 22%, 59% and 94% respectively.

In this study, we termed this as clinical prediction score (CPS) and used the score to predict the success and failure of hydroreduction in children at our institute. The CPS was calculated for the patients and a ROC curve was plotted for the CPS. The optimal cut-off point was found to be 11 and the area under the curve was 0.903 (95% CI, 0.747-1). Sensitivity, specificity, positive predictive value, and negative predictive value were 96, 86, 98, 75 respectively.

Conclusion

Ultrasound-guided saline hydroreduction is an effective and safe procedure for pediatric intussusception. Rectal bleeding, fever and abdominal distension were independent risk factors for failure of hydroreduction. CPS was a good predictor of outcome for hydroreduction.

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