



# Bananagram: an alternative to distal loopogram prior to colostomy closure for Hirschsprung disease

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## ABSTRACT

**Background** This study aimed to investigate if mashed ripe bananas (bananagram) could be used to assess the integrity of the gut before transverse colostomy closure in patients with Hirschsprung disease (HSCR) in a low- and middle-income country tertiary-level hospital.

**Methods** This is a prospective, single-center, hospital-based cohort study. A feeding tube tip was inserted about 5–8 cm through the distal loop, and 15 mL of mashed banana was introduced. The amount introduced and the spontaneous expulsion of mashed banana were measured. We also measured colonic transit time (CTT), input and expulsion ratio, color of the expelled banana stream, size of the banana stream passed through the anus and clinical signs of bowel obstruction or perforation after the procedure.

**Results** From January 2018 to June 2023, 266 HSCR patients with a transverse colostomy were included. The mean±standard deviation (SD) age was 26.45±6.41 months. The median CTT of mashed banana was 8 min (interquartile range (IQR): 4–13 min). The mean amount of mashed banana spontaneously expelled through the anus was 13.25±0.95 mL. More than 90% of patients expelled unchanged mashed bananas, and 9.4% expelled stool-banana mixtures. Banana stream was 0.3–1.5 cm in 257 patients and <0.3 cm in nine patients. These nine patients needed revision pull-through.

**Conclusion** Bananagram can be performed at the bedside. It is easy to perform, cost-effective, available throughout the year and does not pose radiation hazards.

## INTRODUCTION

Infants diagnosed with Hirschsprung disease (HSCR) often require laparotomy with colostomy, particularly in Hirschsprung-associated enterocolitis or with a massively dilated proximal bowel. This is followed by resection of the aganglionic bowel with subsequent coloanal anastomosis.<sup>1,2</sup> Before stoma reversal, the pull-through anastomosis and distal colon are routinely evaluated to rule out any anastomotic leak or stricture by digital rectal examination (DRE) and distal loopogram.<sup>3</sup> Chow *et al.*<sup>3</sup> found 3%–40% morbidity and around 4% mortality after stoma reversal.<sup>3</sup>

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ A distal loopogram is typically performed before colostomy closure to assess the integrity of the gut. However, in many low- and middle-income countries (LMICs), distal loopogram is not always available and affordable and has radiation hazards.

## WHAT THIS STUDY ADDS

⇒ Bananagram is a unique procedure.  
⇒ This study discusses our clinical experience using a bananagram before closure of the transverse colostomy for Hirschsprung disease in an LMIC tertiary-level hospital.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study highlights the importance of performing a bananagram before colostomy closure. It can be conducted at the bedside. It is easy to execute and serves as a cost-effective solution available year-round.

Lawal *et al.*<sup>4</sup> used a distal loopogram to confirm anastomotic integrity before stoma reversal.<sup>4</sup> Some studies have recommended routine use of the distal loopogram, whereas others have reserved this investigation only for cases with clinical suspicion of anastomotic stricture.<sup>5,6</sup>

Distal loopogram is generally performed before closure of the colostomy to assess gut integrity.<sup>7</sup> We found that propulsive movements of the large intestine can be evaluated by mashed ripe bananas; a ‘Bananagram’. When mashed, the consistency of ripe bananas becomes similar to fecal matter. In many low- and middle-income countries (LMICs), distal loopogram is not always available and/or affordable. In addition, the loopogram carries a radiation hazard.

The aim of this study was to determine the utility of the bananagram in evaluating distal



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loop function before transverse colostomy closure for HSCR in an LMIC tertiary-level hospital.

## METHODS

### Patients selection

Patients with HSCR admitted for transverse colostomy closure in the pediatric surgery department of Chattoqram Maa-O-Shishu Hospital, Bangladesh, from January 2018 to June 2023 were included in this study. Patients presenting for rectosigmoid HSCR and long-segment HSCR with transverse colostomy were included. Parental consent was an inclusion criterion. Patients with total colonic aganglionosis, extensive aganglionosis and variants of HSCR were excluded.

### Surgery procedure

After confirming the diagnosis with a full-thickness rectal biopsy, a transverse colostomy was performed in all patients recruited to the study. Six to twelve months later, laparoscopic-assisted transanal endorectal pull-through with coloanal anastomosis was performed in all patients. Next, the colostomy was reversed to restore gastrointestinal continuity and allow for normal defecation 6–9 months after the definitive procedure. Bananagram was performed only once, usually 1 day before transverse colostomy closure.

### Protocol for the bananagram

A 50cc Tommy syringe, rubber sheet, gloves, gauze, one yellow ripe banana, feeding tube, lubricant, stopwatch and measuring scale are required for completion of the bananagram ([figure 1](#)). Patients are positioned supine over a rubber sheet on the bed. After cleaning the stoma, the feeding tube tip (10–14 Fr) was inserted about 5–8 cm through the distal loop. The Tommy syringe was connected to the feeding tube, and 15 mL of mashed banana was introduced. Slow, sustained pressure was

applied to the Tommy syringe plunger, and the mashed banana was pushed into the lumen. The time for spontaneous expulsion of the mashed banana was up to 30 min and the amount introduced and expelled was measured. Spontaneously expelled bananas were collected and transferred back to the 50 cc Tommy syringe for comparison with the preintroduction amount. Our specific objectives were to assess the time for mashed bananas to pass from the distal loop of the stoma through the anus (colonic transit time, CTT), to assess anastomotic stricture by measuring the diameter of the expelled mashed bananas, to detail any complications of the procedure and to assess the parental feedback.

### Measured variables

CTT in minutes was measured. Four to thirty minutes was considered as normal.<sup>8,9</sup> The amount of spontaneously expelled mashed banana from the anus, input and expulsion ratio, color of the expelled banana stream and size of the banana stream passed through the anus (measured with a ruler from one anal margin to another laterally) were measured. Any clinical signs of bowel obstruction or perforation during and after the procedure were also recorded. Parental feedback was evaluated using a Likert scale ranging from 5 (Strongly agree) to 1 (Strongly disagree).

## RESULTS

We enrolled 266 patients in this study. The mean age was  $26.45 \pm 6.41$  months, mean weight was  $10.77 \pm 2.45$  kg, and the male to female ratio was 1.00:1.06 ([table 1](#)). Median CTT of mashed banana was 8 min (interquartile range (IQR): 4–13 min). There were 5 (1.88%) patients had delayed CTT. The mean volume of spontaneously expelled mashed banana through the anus was  $13.25 \pm 0.95$  mL ([table 2](#)). The median input and expulsion ratio of mashed banana was 1.00:0.88.

In 90.6% of patients, expelled mashed bananas were unchanged in color, with the remaining 9.4% of expelled bananas being stool tinged, indicating a small amount of fecal matter within the distal loop. Before colostomy closure, we thoroughly washed the distal loop with normal saline, and rectal irrigation was also given. The amount of stool was negligible and did not require adjustment with the total volume of expelled mashed bananas. The size of the expelled banana stream was 0.3–1.5 cm in 96.6% of patients. In the remaining 3.4% of patients, stream size was <0.3 cm. This raised a suspicion of anastomotic stricture. We performed a DRE under general anesthesia in these patients and found an anastomotic stricture requiring a revision pull-through. There were no complications, such as intestinal obstruction or perforation, during or after the procedure.

No significant correlation were found between the amount of spontaneously expelled mashed banana ( $13.49 \pm 0.67$  mL) and the size of the banana stream



**Figure 1** Items required for bananagram: (1) rubber sheet, (2) gloves, (3) lubricant, (4) normal saline, (5) stopwatch, (6) ripe banana, (7) mashed banana, (8) feeding tube, (9) 50 cc Tommy syringe, (10) measuring scale, (11) gauze.

**Table 1** Demographics of the study population

Variables	Statistics
Age (continuous, months)	26.45±6.41
Age group (months)	
12–24	95 (35.71)
25–36	150 (56.39)
37–48	21 (7.89)
Gender	
Male	137 (51.50)
Female	129 (48.50)
Weight (continuous, kg)	10.77±2.45
Weight group (kg)	
5–10	136 (51.13)
11–15	121 (45.49)
≥15	9 (3.38)
The data was presented as mean±SD or number (%) SD, standard deviation.	

passed through the anus (0.88±0.32 cm) (person  $r=0.015$ ,  $p=0.810$ ).

The average rating for the bananagram procedure from the parental survey (table 3) was approximately 4.93. This suggests that the majority of parents had a very positive experience of the procedure. A small percentage of patients (about 3.7%) experienced discomfort during the bananagram, but overall, they were satisfied with the procedure.

## DISCUSSION

HSCR is an important congenital disease of the colon with a widely varying incidence and presentation.<sup>2,10</sup> There are about 85–90 cases annually in our center in Bangladesh, with male predominance.<sup>11</sup> In our institute, the male to female ratio was 1:1.06 during this study period, and we plan to conduct further detailed research on this in the

**Table 2** Amount of mashed banana spontaneously expelled

Variables	Statistics
Amount spontaneously expelled (continuous, mL)	13.25±0.95
Amount spontaneously expelled group (mL)	
<9.9	0 (0.00)
10–10.9	4 (1.50)
11–11.9	8 (3.01)
12–12.9	21 (7.89)
13–13.9	163 (61.28)
>14	70 (26.32)
The range of amount spontaneously expelled was 11–15 mL.	

future. In newborns, a single-stage transanal pull-through is performed. Because of socioeconomic conditions, many patients come late with huge abdominal distention and features of enterocolitis, requiring a stoma.<sup>2,11</sup> Early stoma closure reduces stoma-related morbidity and patient discomfort.<sup>12</sup>

Prior to stoma closure, a distal loopogram is performed in many centers.<sup>6</sup> However, this is associated with exposure to ionizing radiation, a risk of cancer, and is costly.<sup>13</sup> According to guidelines published by the National Cancer Institute of the USA, the developing tissues of children are more sensitive to radiation than adult tissues.<sup>13,14</sup> Berrington de González *et al.*<sup>14</sup> suggested that the evaluation of the colon may be performed better with intra-operative maneuvers that avoid additional expense and radiation exposure.<sup>14</sup> Hong *et al.*<sup>15</sup> proposed removing the distal loopogram from the treatment algorithm, reducing radiation exposure and decreasing overall healthcare costs.<sup>15</sup>

In our society, simple reintroduction of stools back through the stoma is culturally unacceptable. Also, in our country, an elderly female relative usually helps with the care of young and sick children, and they show reluctance for procedures such as stool reintroduction if there is a stoma bag. However, both parents and family members were comfortable with bananagram.

Bananagram is a unique, non-invasive procedure. It is performed at the bedside to assess the functional status of the gut lumen. Baaleman *et al.*<sup>16</sup> observed that a young infant can defecate 0.6–0.8 ounces (17–24 mL) of stool in each defecation.<sup>16</sup> Fully ripe bananas are mashed here to soften their consistency, like fecal matter. A medium-sized ripe yellow banana can make 18–25 mL of mashed banana. The primary site for the absorption of fructose (sugar) from bananas is the small intestine.<sup>17</sup> Yellow bananas are cheap, available throughout the year, functionally inert, and have no tissue reaction to the large gut mucosa. These factors increase parental acceptability. Indeed, 98.5% of parents reported they were satisfied with the procedure because it is cheap and they can avoid a visit to a radiological laboratory.

Velde *et al.*<sup>18</sup> reported a median left CTT of 1.2 hours (0–3.2 hours) in healthy children.<sup>18</sup> However, in patients with a colostomy, Yasuda *et al.*<sup>9</sup> reported a mean evacuation time after colostomy irrigation of 6 min 56 seconds±2 min; they performed a scintigraphic analysis.<sup>9</sup> Karadağ *et al.*<sup>8</sup> reported that colostomy irrigation usually took 12 min.<sup>8</sup> Colonic evacuation times >30 min in patients with HSCR with colostomy indicate obstruction either by fecaloma, retained barium, or neurological deficit.<sup>8,9,18</sup> In our study, 98.2% of patients passed the mashed banana within 4–30 min. In 1.8% of patients, this was delayed >30 min, and these patients needed fecaloma removal. Occasionally, CTT can be faster at <3 min.<sup>19</sup> This may occur due to unusual sensations in the rectum, abnormal sphincter function and hyperperistalsis of the pull-through bowel.<sup>19</sup> However, none of the patients in our study experienced these problems.



**Table 3** Parental feedback regarding bananagram

Parental feedback	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Score
Items were easily available.	258 (96.99)	8 (3.01)	0 (0.00)	0 (0.00)	0 (0.00)	4.97±0.17
Items used for bananagram were cheap.	254 (95.48)	12 (4.52)	0 (0.00)	0 (0.00)	0 (0.00)	4.95±0.21
Doctors and nurses were cooperative.	257 (96.61)	9 (3.39)	0 (0.00)	0 (0.00)	0 (0.00)	4.97±0.18
I participated spontaneously.	260 (97.74)	6 (2.26)	0 (0.00)	0 (0.00)	0 (0.00)	4.98±0.15
Bananagram was easy to perform.	253 (95.11)	7 (2.64)	6 (2.25)	0 (0.00)	0 (0.00)	4.93±0.33
My child did not feel any discomfort during bananagram.	230 (86.46)	12 (4.52)	14 (5.26)	10 (3.76)	0 (0.00)	4.74±0.72
My child did not feel any discomfort after bananagram.	244 (91.72)	13 (4.89)	9 (3.39)	0 (0.00)	0 (0.00)	4.88±0.41
I was pleased to participate.	258 (96.99)	6 (2.26)	2 (0.75)	0 (0.00)	0 (0.00)	4.96±0.23

Data (n=266) are from a Likert scale survey of parental feedback on the use of bananagram as an alternative to a distal loopogram prior to colostomy closure in children with Hirschsprung disease. The scoring system is as follows: Strongly agree=5, Agree=4, Neutral=3, Disagree=2, Strongly disagree=1.

The data was presented as number (%) or mean±SD.

According to the Bristol Stool Chart, normal stool in healthy children looks like a sausage or snake.<sup>19</sup> It is smooth, soft, and with a typical diameter of 0.5–2 cm.<sup>20,21</sup> If the mashed banana did not pass or passed in a very narrow stream (less than 0.3 cm), this raised suspicion of an anastomotic stricture. In our study, 3.4% of patients presented with a stream size of <0.3 cm, suggesting anastomotic stricture, which was confirmed with DRE under general anesthesia. These patients required a revision pull-through, followed by colostomy closure at a later date.

Performing bedside DRE in children can be challenging, as many are apprehensive and resist the procedure. Conducting anal calibration under anesthesia in the operating theater is not practically feasible in LMICs. This necessitates multiple hospitalizations and can be expensive, which most families cannot afford. The cheap and easy-to-perform bedside bananagram is therefore beneficial for patients who cannot afford distal loopogram.

Bananagram was an easy procedure to perform. About 99.2% of parents were pleased to participate in the procedure. All the items used for bananagram were available and cheap; the average cost was US\$2, making it an affordable option for most healthcare settings. Parents regularly irrigate the distal loop with a soft feeding tube to prevent fecaloma formation, so 97.7% of parents spontaneously participated in this procedure. Very few patients (about 2%) felt discomfort during and after bananagram. Our center had no stoma care nurses, so

the doctor performed the bananagram with a nurse as an assistant. However, where stoma care nurses are available, they can be trained to perform this; there is a specific protocol for bananagram.

Given the novelty of this procedure, both the doctor and the parents were eager to review the results. The overall weighted mean feedback was approximately 4.93 across all items. This is close to 5 on the Likert scale, indicating a strong positive response to the bananagram procedure. The majority of parents expressed strong agreement with all survey statements, particularly those related to availability (over 97%) and cost of items (over 95%), cooperation of medical staff (over 96%), the ease of performing the procedure (over 95%) and minimal discomfort reported for their child both during and after the procedure. The high levels of strong agreement indicate that parents were generally satisfied with the ‘patient-friendly’ bananagram procedure.

In conclusion, bananagram can be performed at the bedside. It is easy to perform, cost-effective, available throughout the year, and does not pose radiation hazards. Parents expressed high satisfaction with this procedure.

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**Ethics approval** This study involves human participants and was approved by the Institutional Human Research Ethics Committee of Chattogram Maa-O-Shishu Hospital Medical College on November 8, 2017 (Reference No CMOSHMC/IRB/2017/07). Everything involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Participants' parents were fully informed about the study and gave their informed consent to participate before taking part. Participants gave informed consent to participate in the study before taking part.

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**Data availability statement** Data are available upon reasonable request.

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