

## Sonography-guided Gastrografin Enema for Meconium Plug Syndrome in Premature Newborns: Preliminary Results<sup>1</sup>

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**Purpose:** To evaluate the usefulness of sonography-guided Gastrografin enema for the diagnosis and treatment of meconium plug syndrome in premature newborns in a neonatal intensive care unit (NICU).

**Materials and Methods:** Fifteen premature newborns underwent 23 sonography-guided Gastrografin enemas on the 8th day of life on average (range: 3 days - 21 days). The gestational age and birth weight (mean  $\pm$  standard deviation) of the patients were  $29 \pm 2$  weeks and  $999 \pm 148$  g, respectively. The diagnosis of meconium plug syndrome was based on relevant clinical and radiological findings. Diluted Gastrografin (1:3, 17 - 45 ml) was administered through a rectal tube under the guidance of sonography until it reached to the cecum. Thereafter, immediate post-procedure and delayed portable abdominal radiographs were taken. All the procedures were done within the NICU. We reviewed the dates of meconium evacuation and the first feeding after the last enema from the clinical data. Radiologically, the timing of the radiographic improvement after the last enema was checked. In cases of distended distal ileum with meconium on pre-enema sonography, follow-up sonography was performed to determine the interval change after gastrografin enema.

**Results:** None of the sonography-guided Gastrografin enemas performed within the NICU caused procedure-related complications. Meconium was evacuated within one day in all patients. In 14 patients, on average, feeding was started on the 7th day and radiographic improvement was observed on the 3rd day. Four of the five patients showing a distended distal ileum with meconium revealed a decrease in ileal distension on follow-up sonography. On the other hand, the other patient, who did not show such a decrease on follow-up sonography, was found to have ileal stenosis during subsequent surgery.

**Conclusion:** Sonography-guided Gastrografin enema is a safe and effective bedside procedure, when performed in the NICU for the diagnosis and treatment of meconium plug syndrome.

**Index words :** Gastrointestinal tract, US  
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Meconium plug syndrome is the mildest and most common form of meconium obstruction in the newborn (1 - 5). In patients with this syndrome, the meconium fails to pass in the first 24 hours of life and, consequently, the viscous meconium plug in the colon. However, the original description may be mostly applicable to the full-term newborn (1). In premature newborns with meconium plug syndrome, there appear to be different manifestations of the disorder. The proximal end of the meconium plug may extend to the proximal colon or the ileum and the first passage of meconium can normally be delayed until the 9th day of life (4, 6 - 9). Some investigators have regarded the disorder, when it occurs in premature newborns, as a separate entity, and have referred to it as "meconium disease" (10). In contrast, other investigators have described it as just one element in the spectrum of meconium disease (11).

Gastrografin enema is a well-established nonsurgical treatment for the various forms of meconium obstruction, including meconium plug syndrome (5, 8, 12). However, it may sometimes be difficult to transport the neonates to the fluoroscopy room (9). The purpose of this study was to evaluate the usefulness of sonography-guided Gastrografin enema for the diagnosis and treatment of meconium plug syndrome in premature newborns in the neonatal intensive care unit (NICU).

### Materials and Methods

This study was approved by our institutional review board. Fifteen premature neonates were included in this study. Their mean gestational age and mean birth weight were approximately  $29 \pm 2$  weeks and  $999 \pm 148$  g, respectively. Eight of them had a maternal history of pregnancy-induced hypertension and four of their mothers were treated with  $\text{MgSO}_4$ . The remaining four mothers did not know the exact names of the drugs that they had received. Nine out of the 15 neonates showed an elevated level of blood magnesium (range: 2.6 - 5.1 mEq/L) and four of their mothers had a history of treatment with  $\text{MgSO}_4$ .

The diagnosis of meconium plug syndrome was based on the relevant clinical and radiological findings. The clinical findings were abdominal distension and bilious vomiting or bile in the gastric content, accompanied by the failure of meconium passage to occur within 48 hours after birth, with this extended time period being used, because all of the neonates were premature. At the same time, there should be no clinical presentations

suggesting necrotizing enterocolitis, including bloody stools or mucous in the stools. The abdominal radiographic findings of meconium plug syndrome were diffuse gaseous distension of bowel loops with no or little rectal air, although these indications were only representative of a nonspecific obstructive bowel gas pattern (13). It should be noted that we could not evaluate the air-fluid levels in the dilated bowel loops, because we usually performed abdominal radiography only in the supine position. In addition, there should be no radiologic findings of necrotizing enterocolitis, including intramural air, portal venous gas, a persistent dilated loop and pneumoperitoneum.

The ultrasound system used in this study was an HDI 3000 (Advanced Technology Laboratories, Bothell, Wash). An either 8 - 5 MHz convex or 12 - 7 MHz linear probe was used. Pre-enema sonography was performed in all patients and focused on the evaluation of the bowel, including the appearance, distribution and amount of intraluminal meconium, any evidence of necrotizing enterocolitis such as bowel wall thickening or intramural air, and the ratio of the diameter of the sigmoid colon to that of the rectum (Figs. 1A, B). All 15 patients fulfilled the clinical and radiological findings of meconium plug syndrome and Gastrografin enema was therefore performed.

Sonography-guided Gastrografin enema was performed entirely in the NICU. The procedure was done on the 8th day of life on average (range: the 3rd day - the 21st day). Its timing was determined by a consensus of opinion among all participating pediatric radiologists and neonatologists. A neonatologist explained the procedure to the parents and received informed consent from them. A pediatric radiologist and a neonatologist worked together as a team in each procedure. Diluted diatrizoate meglumine (Gastrografin, Schering, Berlin, Germany), which contained iodine at a concentration of 93 mg/ml and an osmolality of 538 mOsm/kg, (Gastrografin : sterile water 1 : 3, 17 - 45 ml) was administered through a rectal tube by hand injection via a syringe, until the Gastrografin reached the cecum under sonographic guidance (Figs. 1C, D). Anal leakage of Gastrografin was observed in the first few cases, in which a relatively small-caliber rectal tube was employed, and, consequently, a larger rectal tube was used to maintain tight anal sealing in subsequent cases. An immediate post-procedure portable abdominal supine radiograph was taken, and then follow-up portable abdominal supine radiographs were taken every day, start-

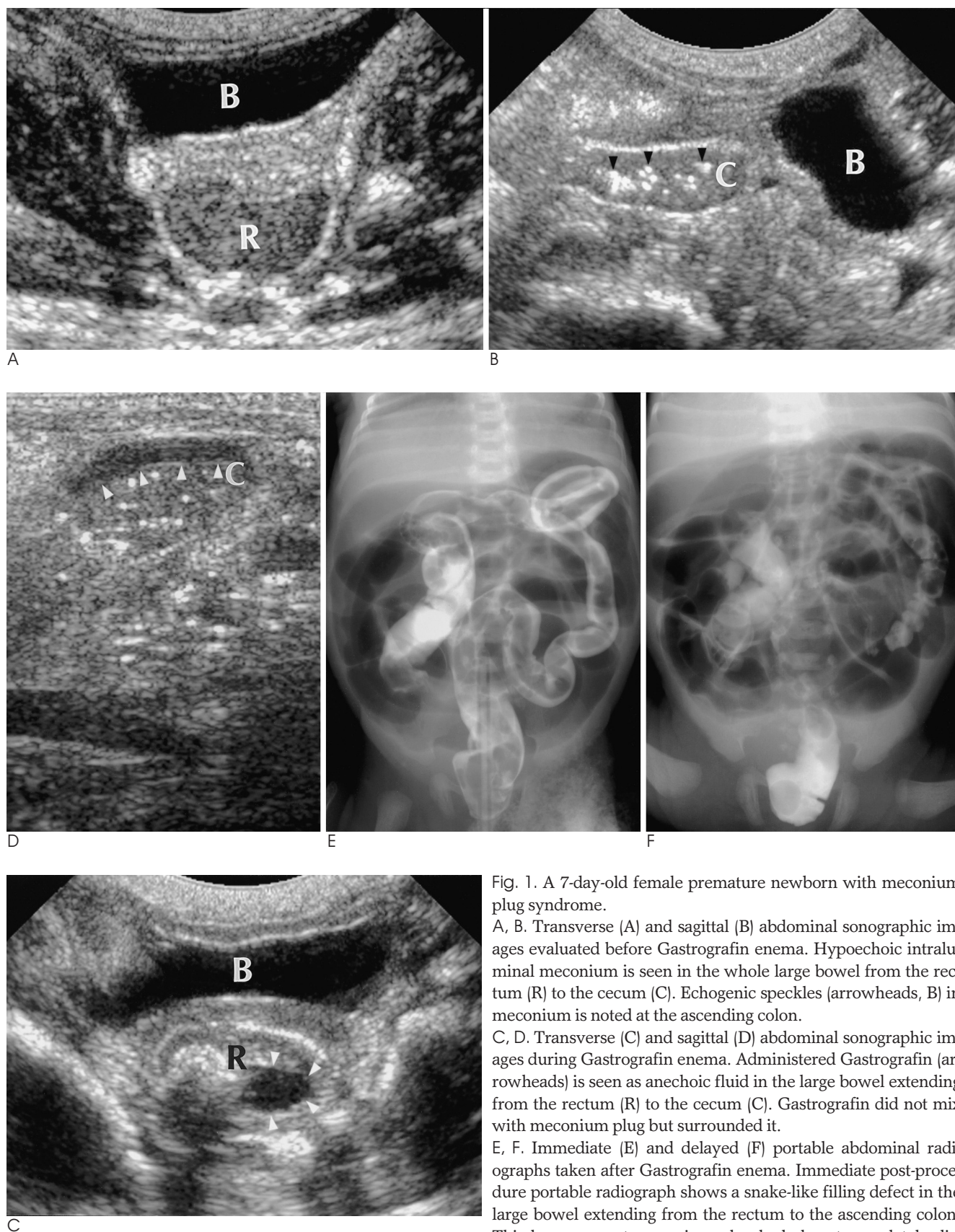


Fig. 1. A 7-day-old female premature newborn with meconium plug syndrome.

A, B. Transverse (A) and sagittal (B) abdominal sonographic images evaluated before Gastrografin enema. Hypoechoic intraluminal meconium is seen in the whole large bowel from the rectum (R) to the cecum (C). Echogenic speckles (arrowheads, B) in meconium is noted at the ascending colon.

C, D. Transverse (C) and sagittal (D) abdominal sonographic images during Gastrografin enema. Administered Gastrografin (arrowheads) is seen as anechoic fluid in the large bowel extending from the rectum (R) to the cecum (C). Gastrografin did not mix with meconium plug but surrounded it.

E, F. Immediate (E) and delayed (F) portable abdominal radiographs taken after Gastrografin enema. Immediate post-procedure portable radiograph shows a snake-like filling defect in the large bowel extending from the rectum to the ascending colon.

This long-segment meconium plug had almost completely disappeared on the delayed portable abdomen radiograph, which was taken 1 hour after enema. Residual Gastrografin in the large bowel and gaseous distension of bowel loops, which improved later, are still seen. Note - B: urinary bladder.



ing from the day on which the meconium plug was evacuated until the gaseous distension of bowel loops was relieved. Gastrografin enema was repeated using the same technique, in cases showing recurrent symptoms and signs of meconium plug syndrome, if and when all of the participating pediatric radiologists and neonatologists concurred on the beneficial effect of additional enema.

Clinical data, such as the evacuation time of the meconium and the starting day of oral feeding after the last enema, and the occurrence of procedure-related compli-

cations, including fluid and electrolyte imbalance, bowel toxicity and perforation were reviewed. For the evaluation of fluid and electrolyte imbalance, the blood chemistry, including the blood sodium and potassium levels, was checked. To survey the occurrence of direct bowel toxicity, symptoms and signs such as abdominal tenderness, gastrointestinal bleeding or diarrhea, suggesting mucosal damage of the bowel and secondary necrotizing enterocolitis were checked. When perforation was suspected on supine radiography, a cross-table lateral abdominal radiography and abdominal sonography

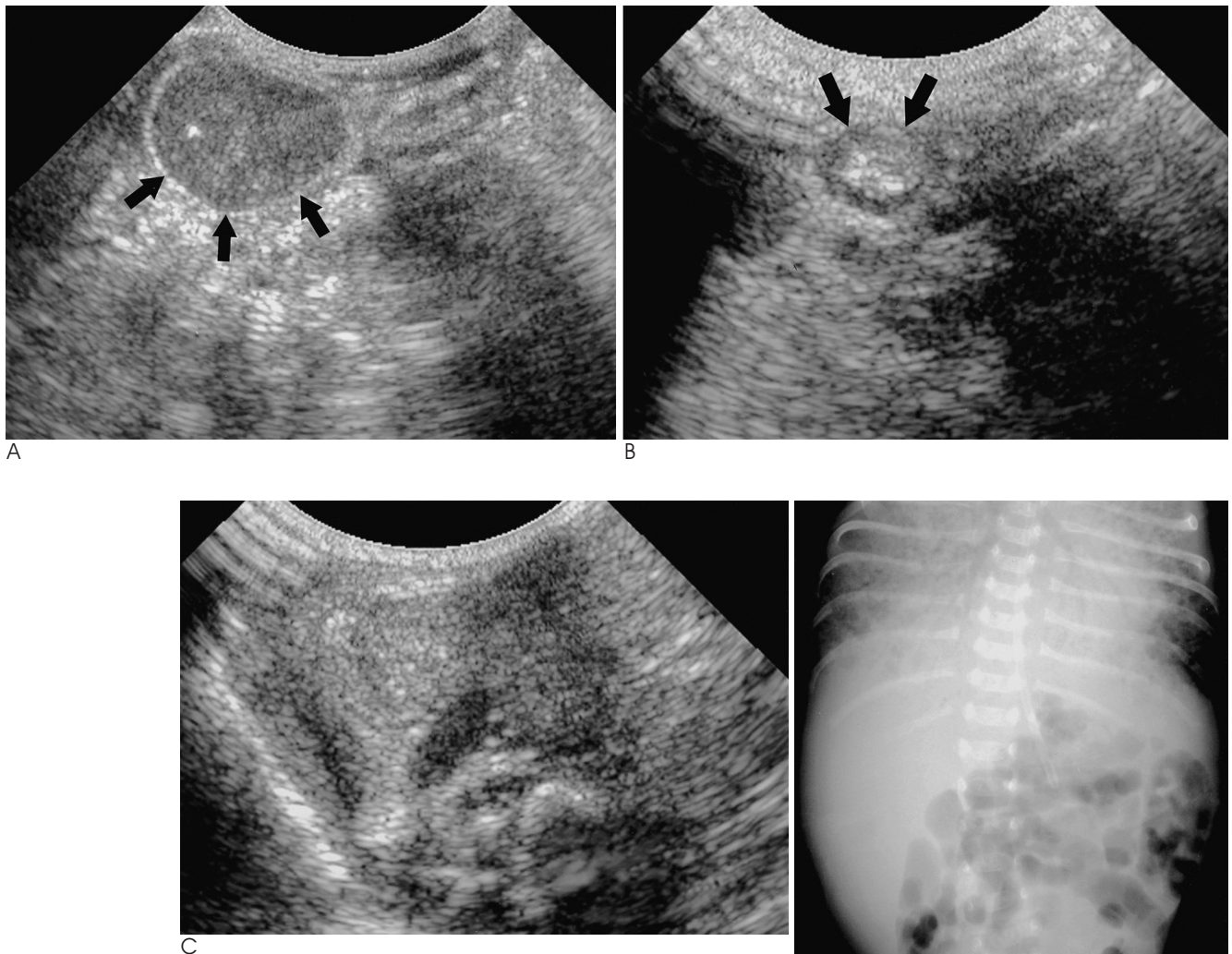


Fig. 2. A 7-day-old male premature newborn with meconium plug syndrome and distended ileum.

A, B. Transverse abdominal sonographic images reveal the distended ileum (arrows) filled with meconium and the smaller ascending colon (arrows) filled with echogenic meconium and echolucent Gastrografin.

C. Transverse abdominal sonography encompassing the right lower quadrant of the abdomen, which was taken 16 days later, shows resolution of distended ileal loops.

D. Portable abdominal radiograph taken 1 month later displays near normalization of bowel gas pattern.

were performed. A pediatric radiologist checked the timing of the improvement in abdominal distension on the abdominal radiography performed after the last enema. The anatomic location of the meconium-filled bowel was determined by tracing the large bowel. In the right lower quadrant of the abdomen, identification of the ascending colon and cecum was helpful in discriminating the meconium-filled ileum from the meconium-filled large bowel, and Gastrografin did not usually enter the meconium-filled ileum during Gastrografin enema. The definition of a distended distal ileum was relative, and no absolute size criterion was applied. In cases of distended distal ileum with meconium on pre-enema sonography, follow-up sonography was performed to determine the interval change after gastrografin enema.

## Results

We observed hypoechoic intraluminal material with scattered echogenic speckles in the large bowel on abdominal sonography. Moreover, sonography enabled us to exclude other obstructive lesions, such as malrotation with or without midgut volvulus, duplication cyst and Meckel's diverticulum. Meconium in the distal ileum in addition to the large bowel was detected on pre-enema sonography in eight patients, and five of these patients had a distended distal ileum due to the presence of a large amount of meconium (Fig. 2). In the remaining seven patients, meconium was present only in the large bowel, between the rectum and the cecum. The pres-

ence of a distended rectum with meconium was observed in five patients, and two of these patients also had meconium in the distal ileum. There were no evidence of necrotizing enterocolitis in the sonographic findings, and the ratio of the diameter of the sigmoid colon to that of the rectum was within the normal range in all patients. Immediate post-procedure abdomen radiography depicted a normal-caliber colon in fourteen patients, whereas a microcolon was detected in one patient (Figs. 1E, 3B).

Gastrografin enema was repeated in five patients (Table 1). The frequency of Gastrografin enemas per patient was once in 10 patients, twice in two, and three-times in three. Therefore, a total of 23 Gastrografin enemas were performed in 15 premature newborns. There were no procedure-related complications either during or after the Gastrografin enema. Five patients underwent cross-table lateral abdominal radiography after the enema, but their radiographic findings were all negative.

Clinically, meconium was evacuated within one day after the last enema in all patients (9 patients on the same day, 6 patients on the next day) though its amount and frequency were variable, and feeding was started on the 7th day  $\pm$  5 days after the last enema on average. Radiographic improvement after the last enema was seen on the 3rd day  $\pm$  2 days on average. The timing of oral feeding did not match with the timing of radiographic improvement (Table 1). Distended distal ileum due to the presence of a large amount of meconium was

Table 1. Timing of Oral Feeding and Radiographic Improvement after Gastrografin Enema

Case Number	Age at Gastrografin Enema (Day)			Oral Feeding (Days)	Radiographic Improvement (Hours)
	1st	2nd	3rd		
1*	10	16	21	No	No
2*	10			1	165
3*†	8			12	118
4*†	7			6	67
5*	7	7		9	60
6	4	7		5	67
7†	10			6	62
8†	10			10	60
9	7			4	48
10†	3	5	11	4	46
11†	7			3	41
12†	3			2	24
13	10			20	22
14†	4			7	18
15†	3	3	4	9	18

Note. - \* Cases showing distended distal ileum with meconium on pre-enema sonography, † Cases showing elevated level of blood magnesium. Case 1, who underwent ileocecal resection and end-to-end anastomosis due to ileal stenosis, did not start oral feeding and did not show radiographic improvement prior to surgery.

significantly correlated with delay in radiographic improvement, but not with delay in oral feeding after the Gastrografin enema. Four of the five patients having a distended distal ileum with meconium showed a decrease in ileal distension on follow-up sonography (Fig. 2). In contrast, one patient (case 1) in whom a microcolon was observed on initial sonography and whose ileal distension remained on follow-up sonography was found to have ileal stenosis during subsequent surgery (Fig. 3).

### Discussion

Gastrografin enema is a safe and effective nonsurgical treatment for meconium plug syndrome (5, 8, 9, 12). In our study, we were able to perform Gastrografin enema

entirely in the NICU, which is a safer place for premature newborns than a fluoroscopy room. Furthermore, we reduced radiation exposure by using sonographic guidance instead of fluoroscopic guidance.

In this study, the timing of oral feeding and radiographic improvement after the Gastrografin enema were not well matched. We believe that this may be due to a certain number of confounding factors, including respiratory distress, neurologic impairment, sepsis and drugs. The distension of the distal ileum due to the presence of a large amount of meconium seemed to be correlated with delay in radiographic improvement, but not with delay in oral feeding after the Gastrografin enema. This sonographic finding disappeared or decreased after the enema in patients in whom clinical and radiological conditions had improved and oral feeding could start,



A

Fig. 3. A 4-day-old female premature newborn with ileal stenosis and distended ileum.

A. Transverse abdominal sonography shows the distended ileal loops ( \* ) filled with meconium and a small amount of ascites.

B. Portable abdominal radiograph after Gastrografin enema reveals microcolon and remaining meconium plug in the rectosigmoid portion of the large bowel.

C. Follow-up sagittal abdominal sonography taken 11 days later demonstrates increased distension of the ileal loops ( \* ).

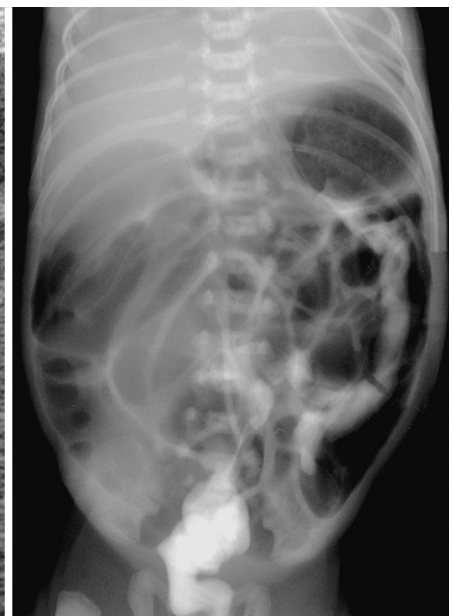
D. Follow-up portable abdominal radiograph taken at the same time as C displays severe gaseous distension of bowel loops and residual Gastrografin in the large bowel.



B



C



D



except for one patient whose condition was complicated with ileal stenosis. Therefore, the distended distal ileum with meconium may not be a contraindication to attempting Gastrografin enema in meconium plug syndrome. However, the presence of an underlying obstructive lesion, such as ileal stenosis, should be considered when a microcolon is present and the distended distal ileum does not decrease on follow-up sonography after the Gastrografin enema, as in the case of one of our patients.

Two important conditions should be correctly differentiated from meconium plug syndrome prior to performing Gastrografin enema. The first condition is necrotizing enterocolitis, which is relatively prevalent in premature newborns (9, 10). Gastrografin enema is contraindicated for this condition, because the bowel toxicity of Gastrografin is apt to aggravate the already compromised bowel (14). Sonography has been reported to improve the diagnostic yield, by identifying bowel wall thickening, pneumatosis intestinalis, portal venous gas, pneumoperitoneum and ascites earlier than abdominal radiography (15). In our study, sonographic surveillance prior to the enema enabled us to rule out Gastrografin enema for those patients with necrotizing enterocolitis.

The next condition that should be correctly differentiated from meconium plug syndrome is Hirschsprung's disease, because corrective surgery is necessary for its treatment (4, 13). In typical cases, sonography may reveal a transition zone in the rectosigmoid area of the large bowel and, in this case, the patients involved should undergo further confirmatory evaluation. Although these sonographic findings in newborns with Hirschsprung's disease have not been evaluated for their diagnostic accuracy, we have experienced a few such cases (unpublished data). Additionally, the pre-enema sonography can detect obstructive lesions necessitating surgery, such as duplication cyst, Meckel's diverticulum, and rare intussusception (16).

Meconium ileus was not considered in the differential diagnosis because cystic fibrosis is virtually absent in our country. Nevertheless, the diagnosis of meconium ileus should be considered if there is only meconium in the terminal ileum, especially in countries where cystic fibrosis is common.

Maternal history of pregnancy-induced hypertension and neonatal hypermagnesemia were frequently present in our study. However, the presence of these two factors seemed to have no association with either the severity of meconium plug syndrome or delay in recov-

ery after Gastrografin enema (Table 1). This may be explained by the fact that these two factors are known to depress intestinal peristalsis transiently for no more than 2 weeks (8, 9, 17). In our study, Gastrografin enema was performed on the 8th day of life on average, when the effect of these two factors was diminished or absent. Moreover, premature neonates may be less influenced by these two factors than full-term neonates, because the bowel function of premature neonates is immature.

The validity of the present study in determining the safety and effectiveness of sonography-guided Gastrografin enema in patients with meconium plug syndrome was limited by the small number of patients and the absence of a comparative control group. However, the safety and effectiveness of Gastrografin enema in the treatment of meconium plug syndrome have been well established by many previous studies. Therefore, the present study highlights the technical applicability of Gastrografin enema in the NICU as a bedside procedure under sonographic guidance. However, it should be mentioned that a gravitational injection may be safer, because perforation can occur with the hand injection method used in our study.

In conclusion, sonography-guided Gastrografin enema is a safe and effective bedside procedure, when performed in the NICU for the diagnosis and treatment of meconium plug syndrome. We believe that the availability of this bedside procedure may enable Gastrografin enema to be used more frequently, particularly for premature newborns.

## References

1. Clatworthy HW Jr, Howard WH, Lloyd J. The meconium plug syndrome. *Surgery* 1956;39:131-142
2. Stewart DR, Nixon GW, Johnson DG, Condon VR. Neonatal small left colon syndrome. *Ann Surg* 1977;186:741-745
3. McAlister WH, Kronemer KA. Emergency gastrointestinal radiology of the newborn. *Radiol Clin North Am* 1996;34:819-844
4. Loening-Baucke V, Kimura K. Failure to pass meconium: diagnosing neonatal intestinal obstruction. *Am Fam Physician* 1999;60:2043-2050
5. Fuchs JR, Langer JC. Long-term outcome after neonatal meconium obstruction. *Pediatrics* 1998;101:E7
6. Siegel MJ, Shackelford GD, McAlister WH. Neonatal meconium blockage in the ileum and proximal colon. *Radiology* 1979;132:79-82
7. Shigemoto H, Endo S, Isomoto T, Sano K, Taguchi K. Neonatal meconium obstruction in the ileum without mucoviscidosis. *J Pediatr Surg* 1978;13:475-479
8. Amodio J, Berdon W, Abramson S, Stolar C. Microcolon of prematurity: a form of functional obstruction. *AJR Am J Roentgenol* 1986;

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