

## CONCLUSION

SPECT bone scanning of the knee is superior to planar imaging in detecting ACL injury and is a sensitive examination in a population of patients predominantly with chronic ACL tears. Sensitivity may be dependent on the chronicity of symptoms although acute tears and both partial and complete tears can be identified.

Focal activity at either end of the ACL attachments may be seen, but the more common appearance is of a single, focal abnormality in the medial aspect of the posterior, lateral femoral condyle. This pattern has not been previously reported in patients with acute tears and may therefore occur more frequently in those with chronic symptoms.

SPECT imaging of the knee may be a valuable examination in suspected ACL injury particularly if MRI is not available, if MRI is equivocal or if the clinical signs do not support a diagnosis of ACL tears detected by MRI. In addition, knee SPECT is able to localize other areas of injury within the knee associated with ACL tears.

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# Pediatric Gastric Emptying: Value of Right Lateral and Upright Positioning

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Gastroesophageal reflux and gastric emptying are usually assessed simultaneously with a 1-hr procedure. After ingestion of radiolabeled formula sequential images are gathered when the infant is in the supine position. This position is adequate for gastroesophageal reflux assessment, but delays gastric emptying. **Methods:** We studied 48 children, 1 wk to 2 yr of age, who presented with vomiting or failure to thrive. They received  $^{99m}\text{Tc}$ -sulphur colloid in formula. After completing 1 hr supine imaging we obtained additional abdominal views after changing the position of the infant to right lateral for 30 min, and upright for another 30 min. **Results:** The percent of gastric emptying at 60 min in the supine position was  $35\% \pm 19\%$ . At 90 min, in the right lateral decubitus, the percent gastric emptying was  $60\% \pm 25\%$ . At 120 min, after an upright period, the gastric emptying was  $73\% \pm 20\%$ . In the supine position 19 of 48 patients showed significant emptying (defined as  $>40\%$  emptying). This increased to 41 of 48 normal studies considering the right lateral position and to 45 of 48 normal studies considering the infant upright position. **Conclusion:** Many patients with delayed gastric emptying show significant emptying just by changing position. We routinely complement gastric emptying studies with delayed views in the right lateral and upright position.

**Key Words:** delayed gastric emptying; pediatric gastric emptying; gastroesophageal reflux; technetium-99m-sulphur colloid

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A concern in infants with recurrent pulmonary infections, failure to thrive and vomiting is the presence of gastroesophageal reflux or delayed gastric emptying. Gastroesophageal reflux is routinely assessed with radionuclide scintigraphy or

pH probing (1,2). The pH probe is the most sensitive method but the radionuclide method, although less sensitive, is thought to be more physiologic and is widely used (3). The association of gastroesophageal reflux and delayed gastric emptying is questionable (4-6) but it still is desirable to evaluate both in one study. Many methods have been proposed to measure gastric emptying: ultrasonic examination (7); epigastric impedance (8) and dual-isotope with combined solid and liquid meal (9); and either liquid or formula (1). Of all these, the milk scan is the most physiologic, allowing evaluation of gastroesophageal reflux and delayed gastric emptying in one setting. With this procedure formula labeled with  $^{99m}\text{Tc}$ -sulphur colloid ( $^{99m}\text{Tc}$ -SC) is administered to the infant and images in the posterior projection are gathered every minute seeking the presence of gastroesophageal reflux. During the 1-hr acquisition, the infant is in the supine position and gastric emptying is assessed with the results reported as percent emptying or retention at 1 hr or halftime emptying. The variability of these results has been considerable and has cast doubt on the clinical utility of the test in small infants (3-6,10-12).

In addition we encountered many discrepancies between radiologic upper gastrointestinal series and nuclear gastric emptying studies. We explored this discrepancy and decided that positioning was a problem. The standard position in upper gastrointestinal studies is right anterior oblique, with the right side of the infant down, this enhances gastric emptying. Also, this is more physiologic because babies are fed in the right lateral semi-upright position.

In this study, at the end of 60 min supine imaging, we gathered two additional views: one after changing the infant to the right lateral decubitus, and another after holding the infant

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upright. With this protocol, we sought to identify those patients with true delayed gastric emptying from those with positional delayed emptying.

**METHODS**

We recruited patients from the pediatric clinic referred for gastric emptying studies. The patient's chief complaints were vomiting, failure to thrive, gastrointestinal bleeding and aspiration pneumonia. Some patients had more than one clinical presentation. We excluded patients with a nasogastric tube, previous gastrointestinal surgery or technically inadequate studies. We studied 48 children (aged 1 wk to 4 yr, 20 boys and 24 girls). All studies were performed with the patient fasting at least 2 hr. We did not study normal control subjects.

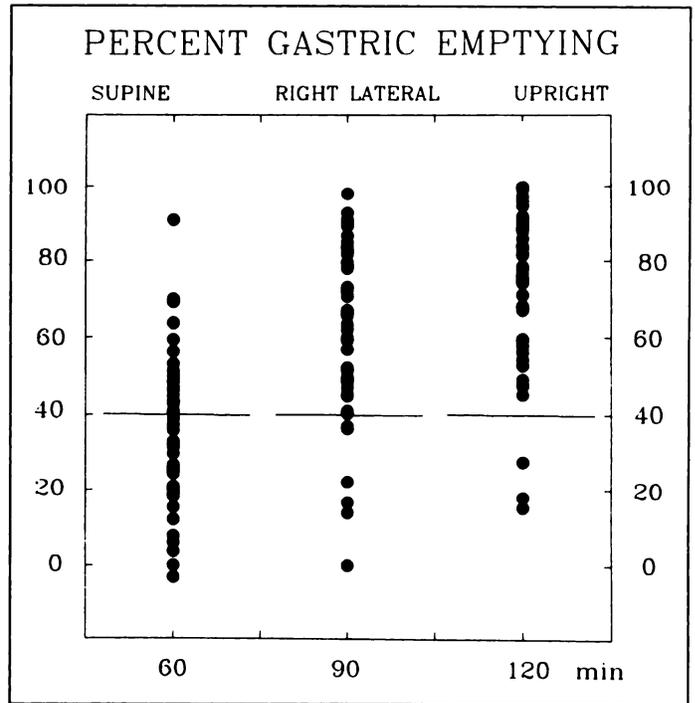
All patients received the type and amount of formula they usually consumed. We added to the preparation 18–37 MBq (0.5–1 mCi) <sup>99m</sup>Tc-sulphur colloid (<sup>99m</sup>Tc-SC). It was not practical to standardize the formula because of specific dietary needs of some infants and because others were finicky. The volume ingested by mouth ranged from 5 to 50 ml. After consuming the labeled formula the infants consumed an aliquot of nonradionuclide formula to clear activity from the mouth and esophagus. Within 5 min of consuming the formula, the infants were placed supine on an imaging table. The infants were firmly restrained to a comfortable supine position and did not change position for 1 hr. A large field of view gamma camera gathered images every 60 sec for 1 hr from the posterior projection. The camera used a low-energy, medium resolution collimator. The acquisition matrix was 64 × 64 pixels, 16 pixels depth. After completing the 1-hr supine acquisition, the infant was placed in the right lateral position for 30 min. At the end of this period, the infant was placed supine for 5 min and a static image gathered. Then the mother or nurse held the infant upright for 30 min. At the end of 30 min in the upright position, the infant was placed supine for 5 min and another posterior image was gathered.

To determine gastroesophageal reflux, the sequential supine images, from the first hour, were reviewed in a cine loop. Image interpretation was done from the monitor lowering the threshold to detect any esophageal activity. For the gastric emptying analysis, we condensed frames to 5-min intervals. This gave high-count density and improved resolution for stomach region of interest definition. We analyzed images at four time intervals: T0 = after completing the meal, T60 = at the end of 60 min supine, T90 = after 30 min in the right lateral position and T120 = after 30 min upright. Decay correction was used for all measurements. A calculation of the percent gastric emptying at T60, T90 and T120 was done. We defined normal gastric emptying as more than 40% emptying at 1 hr. We also considered normal the decrease to <40% from baseline when changing positions.

We also estimated gastric emptying at 90 min (90) and 120 min (120). The estimations were derived from extrapolation of the first hour emptying rate to 90 and 120 min. These values estimate the gastric emptying assuming no change in position and maintaining a similar emptying rate than the one observed during the first hour in the supine position.

**RESULTS**

The average emptying of the stomach in 48 patients at 60 min was 35% ± 19%. At 90 min, the average value was 60% ± 25% and at 120 min was 73% ± 20% (Fig. 1). Placing the threshold at 40% emptying at 1 hr, 19 of 48 (40%) patients show normal gastric emptying. Waiting an additional 30 min and changing the infant to the right lateral position, the percent of patients with normal emptying increased to 85% (41 of 48). An additional 30 min in the upright position increases this

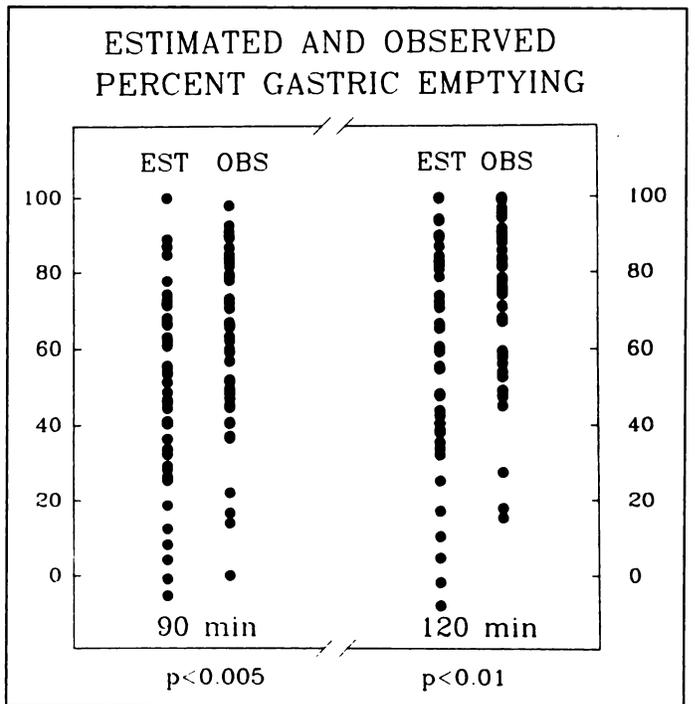


**FIGURE 1.** Percent gastric emptying at the end of 60 min in the supine position; at 90 min after the formula feed and after a period in the right lateral position; and at 120 min after the upright period.

percent to 94% (45 of 48). The observed gastric emptying rate (90 and 120) was faster than the estimated emptying rate (90 and 120) ( $p < 0.001$ ) (Fig. 2).

**DISCUSSION**

Children and neonates with gastrointestinal disorders are among the most frequently seen by the pediatrician. The



**FIGURE 2.** Estimated and observed gastric emptying at 90 and 120 min. Estimated values are an extrapolation of the emptying rate in the first hour. The observed emptying rates are significantly faster when changing positions to the right lateral and upright position ( $p < 0.005$  and  $p < 0.01$  by paired Student's t-test).

development of specialized pediatric gastrointestinal units has led to the need for more specific answers to the questions presented by the manifestations of gastrointestinal diseases. In terms of vomiting and reflux, nuclear scintigraphy has higher sensitivity for the detection of gastroesophageal reflux compared to barium contrast studies (1). Furthermore, it provides physiologic information which complements the anatomic detail obtained with radiography and ultrasound. Gastrointestinal scintigraphy is physiologic, noninvasive and quantitative. Frequently in one study both gastroesophageal reflux and gastric emptying are evaluated.

Normal gastric emptying values are not available because truly normal children are not studied. However, 40% emptying of milk at 1 hr and 60% emptying at 2 hr is generally considered normal (13). Maxson reports as normal to have at least 32% emptying at 60 min (14) while Buchmiller and Fonkalsrud consider more than 40% emptying at 90 min as normal (15). Krausz reports delayed gastric emptying as more than 63% retention at 30 min and more than 37% retention at 2 hr (16).

With our study we were able to further retime the test by separating patients with true delayed emptying from those with apparent delayed gastric emptying by adding two positional changes after imaging in the supine position. The percent of infants with normal gastric emptying increased from 40% to 85% and 94%.

A limitation of this study is the assumption that formula gastric emptying is monoexponential in children. We presume that the emptying rate of the stomach stays constant throughout the procedure. However, the extrapolation from the first hour could not necessarily predict the values at 90 and 120 min. A complementary study would be required to study a group of patients in the supine position for 120 min and compare them to the group with altered position. Also, small volumes of formula may have different emptying rates than larger volumes. The importance of these observations for clinical management of children is unknown.

Another consideration of this study is that a single posterior projection was used. Anterior and posterior images allow us to estimate the geometric mean, and correct for attenuation (10). Because we studied small infants, who characteristically have sparse soft tissues, the likelihood for significant attenuation is small.

## CONCLUSION

We have combined the evaluation for gastroesophageal reflux and gastric emptying in a 2-hr study. The delayed views improved discrimination of delayed versus normal but positional related delayed gastric emptying. This observation has important implications for management. We suggest that gastric emptying studies be altered in a fashion similar to that outlined in this paper. We have now adopted this format as our standard in our institution.

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