

Gastric emptying time: a comparison between geometric mean and left anterior oblique methods.

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Objective : *To compare the gastric emptying times as determined by the geometric mean method and left anterior oblique method.*

Setting : *Division of Nuclear Medicine, Department of Radiology, Faculty of medicine, Chulalongkorn Hospital.*

Research design : *Prospective study*

Subject : *Twenty normal volunteers and 34 non-ulcer dyspeptic patients were recruited into the study.*

Methods : *The solid meal gastric emptying time was measured scintigraphically using 0.5 mCi of Tc-99m Phytate labeled microwave-cooked eggs. Gastric emptying times and lag phases were calculated from gold standard method to obtain geometric mean using data from anterior and posterior projections and from a simpler method using a 30 degree left anterior oblique projection. The significant*

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differences of these two methods were tested using the paired student t-test. A correlation of gastric emptying times of the methods was determined by regression analysis.

Results : *There was no significant difference of gastric emptying times and lag phases as determined by the geometric mean and left anterior oblique methods (p value > 0.22 and 0.12 respectively). Correlation of gastric emptying times of the two methods was good with a correlation coefficient (r) = 0.957 and standard error of estimation ($Sy.x$) = 8.298 minutes.*

Conclusion : *Gastric emptying times determined by the left anterior oblique method are accurate and can be used for routine investigations. This method provides simple data acquisition and analysis.*

Key words : *Gastric emptying time, Solid meal, Scintigraphic study.*

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วัตถุประสงค์ : เพื่อเปรียบเทียบค่าเวลาของการรับประทานอาหารของกระเพาะอาหารที่คำนวณด้วยวิธีค่าเฉลี่ยจีโอเมตริกกับวิธีถ่ายภาพเงี่ยงหน้าด้านซ้าย

สถานที่ที่ทำการศึกษา: สาขาเวชศาสตร์นิวเคลียร์ ภาควิชารังสีวิทยา คณะแพทยศาสตร์ โรงพยาบาลจุฬาลงกรณ์

รูปแบบการวิจัย : การศึกษาไปข้างหน้า

ผู้ป่วยที่ทำการศึกษา : อาสาสมัครปกติ 20 ราย และผู้ป่วย *dyspepsia* ที่ไม่มีแผลในกระเพาะอาหาร 34 ราย

วิธีการศึกษา : วัดเวลาของการรับประทานอาหารแข็งและ *lag phases* ของกระเพาะอาหารด้วยวิธีการทางเวชศาสตร์นิวเคลียร์ อาหารแข็งดังกล่าวคือไข่ไก่ติดฉลากด้วย $Tc-99m$ Phytate 0.5 มิลลิคูรี ซึ่งทำให้สุกด้วยเตาไมโครเวฟ ทำการคำนวณเวลาของการรับประทานอาหารแข็งและ *lag phases* ของกระเพาะอาหารจาก 2 วิธีคือ วิธีค่าเฉลี่ยจีโอเมตริกซึ่งเป็นวิธีมาตรฐานกับวิธีถ่ายภาพเงี่ยงหน้าด้านซ้าย จากนั้นเปรียบเทียบหาความแตกต่างระหว่างค่าที่คำนวณได้จากทั้งสองวิธีด้วยสถิติ *paired student t-test* และหาความสัมพันธ์ระหว่างเวลาของการรับประทานอาหารแข็งที่คำนวณด้วยวิธีทั้งสองด้วยวิธีสถิติถดถอยเชิงเส้น

ผลการศึกษา : ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติของเวลาของการรับประทานอาหารแข็งและ *lag phase* ของกระเพาะอาหารที่วัดด้วยวิธีค่าเฉลี่ยจีโอเมตริกกับวิธีถ่ายภาพเงี่ยงหน้าด้านซ้าย (ค่า *p* มากกว่า 0.22 และ 0.12 ตามลำดับ) และเวลาของการรับประทานอาหารแข็งที่คำนวณด้วยวิธีทั้งสองมีความสัมพันธ์กันเป็นอย่างดี โดยมีค่าสัมประสิทธิ์ความสัมพันธ์ (*r*) = 0.957 และค่าความผิดพลาดมาตรฐาน (*Sy.x*) = 8.298 นาที

สรุป : เวลาของการรับประทานอาหารแข็งของกระเพาะอาหารที่วัดด้วยวิธีถ่ายภาพเงี่ยงหน้าด้านซ้ายซึ่งสามารถทำได้ง่ายกว่า มีความถูกต้องสามารถนำมาใช้ในการตรวจผู้ป่วยในทางคลินิกได้เป็นอย่างดี

คำสำคัญ : เวลาของการรับประทานอาหารของกระเพาะอาหาร, อาหารแข็ง, วิธีการตรวจทางเวชศาสตร์นิวเคลียร์

Gastric emptying times are useful for evaluation of gastric functions, especially in patients with non-ulcer dyspepsia. Quantitative methods using radionuclides have proven to be the most accurate and physiologic procedures.⁽¹⁻³⁾ The principle of the technique is very simple. After the ingestion of a standard meal, an external detector can be used to determine the quantity of radioactive material in the stomach as a function of time. The gastric emptying time (GET) can then be calculated. For the postero-anterior position of the stomach, attenuation compensation is necessary. Conventionally, this compensation is based on the geometric mean (GM), applied to different static images taken at regular intervals.^(4,5) Although the GM method has been shown to be straightforward and effective, it requires the acquisition of both anterior and posterior views which, in turn, necessitates the use of a dual-headed gamma camera. If only a single-headed gamma camera is available, frequent repositionings of the patient during the course of the study have to be performed. But this prevents dynamic data acquisition and hence makes an accurate characterization of the gastric emptying curve impossible. If a dual-headed camera is not available, a method of attenuation compensation that will allow continuous dynamic acquisition from a single view is needed. Other advantages of single view acquisition include less patient positioning and easier processing. There have been few reports using the left anterior oblique (LAO) view for attenuation compensation. This

method should permit an accurate and precise GET calculation from a single view.^(6,7) The aim of our study was to determine if there was a significant difference in GET measurement by the GM and LAO methods.

Materials and Methods

Subjects and acquisition methods

Studies were performed on 20 normal volunteers; 7 males, 13 females (age 28.3 ± 9.5 years) and 34 dyspeptic patients; 15 males, 19 females (age 34.3 ± 8.6 years) using a solid meal consisting of 250 grams of cooked rice, two microwave-cooked eggs and 125 ml of pure water with a total energy value of approximately 600 kcal. Half a mCi of Tc-99m phytate was added into the raw eggs, then stirred until well mixed. The mixture was then cooked in the microwave for 2.5 minutes. The meal was eaten within 10 minutes. The subjects were imaged while standing. One-minute static projection of anterior, posterior and 30 degree left anterior oblique (LAO) views were obtained at 0, 10, 20, 40, 60, 80, 100 and 120 minutes after the meal, using a large field gamma camera, and low energy general purpose collimator with a 128 x 128 matrix size.

Gastric emptying time and lag phase calculation

Data from each stomach region of interest (ROI) was corrected for Tc-99m decay. Geometric mean counts were calculated using corrected anterior and posterior counts as shown in equation 1.

Geometric mean counts = (anterior counts
x posterior counts)^{1/2} ...1

Two gastric emptying time-activity curves
were then generated. The first curve using GM
counts and the second curve using LAO view
counts on Y axis, plotted against time in minutes
on X axis.

Usually, such curves consist of 2 phases,
the initial lag phase where there are no changes
of activity in the stomach and the final phase of
declining activity over time. The linear least-
squares fit were applied to the final declining phase
(Fig.1) of both curves to obtain linear regression
equations.

$$\text{Counts} = \text{Time} \times \text{constant1} + \text{constant 2} \dots 2$$

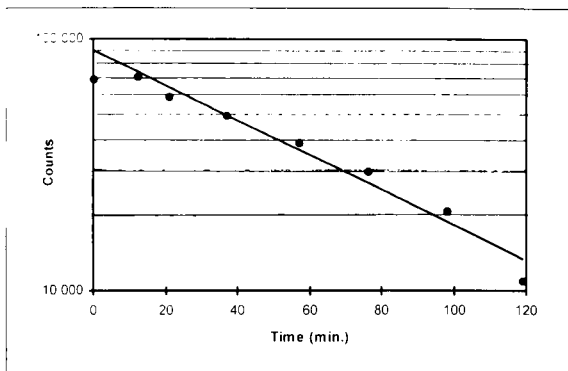


Figure 1. Counts in the stomach region were plot
on Y axis (log scale) against time on X
axis (linear scale) (data were shown in
dot), then linear least-square fit (line)
was applied to the final declining phase
which, in this example, were 2nd to 8th
data points.

Then, using the highest counts as 100%
counts, gastric emptying time, which is time when
counts in the stomach decreased by 50%, was
calculated from each linear regression equation.
And by applying the highest counts to the regres-
sion equation, the calculated time is lag phase.

Statistical analysis

The paired student t-test was used to test
the significant difference of gastric emptying
times and lag phase obtains from the GM method
and the LAO method. Linear regression analysis
was used to determine the correlation of gastric
emptying time of both methods.

Results

Table 1. show mean and standard devia-
tions of gastric emptying times calculated by the
two methods, both in normal volunteers and the
patients, Table 2. show means and standard devia-
tions of lag phase calculated by the two methods
both in normal volunteers and patients. There are
no significant difference of gastric emptying time
(p value > 0.22) and lag phase (p value > 0.12)
calculated by GM or LAO methods both in the
normal volunteers and among the patients, and
also when both groups were combined.

Figure 2. illustrates the linear regression
analysis results of gastric emptying times for both
methods. The correlation coefficient (r) is 0.957
and the standard error of estimation (Sy.x) is 8.298
minutes.

Table 1. Gastric emptying times calculated by geometric mean (GM) and left anterior oblique (LAO) methods in normal volunteers and patients.

Gastric Emptying Time			
	GM method (mean ± SD)	LAO method (mean ± SD)	Paired t-test (p value)
Normal volunteers n = 20	85.6 ± 17.4	85.7 ± 18.1	0.9507
Patients n = 34	88.7 ± 27.6	90.7 ± 33.1	0.2221
Total n = 54	87.5 ± 24.2	88.9 ± 28.3	0.2705

Table 2. Lag phase calculated by geometric mean (GM) and left anterior oblique (LAO) methods in normal volunteers and patients.

Lag Phase			
	GM method (mean ± SD)	LAO method (mean ± SD)	Paired t-test (p value)
Normal volunteers n = 20	9.5 ± 6.5	11.5 ± 9.7	0.3054
Patients n = 34	11.4 ± 9.0	13.8 ± 12.6	0.2386
Total n = 54	10.7 ± 8.1	12.9 ± 11.5	0.1216

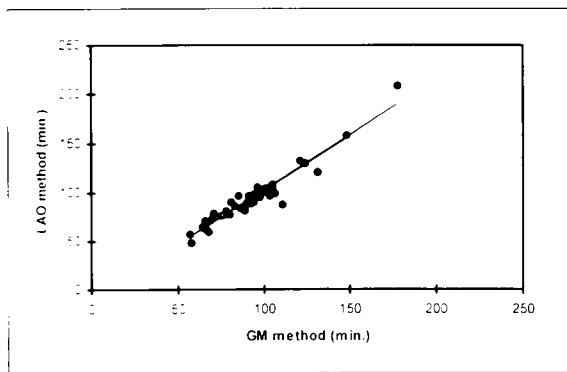


Figure 2. The linear regression analysis result of gastric emptying time from both methods. The correlation coefficient (r) was 0.957 and standard error of estimation ($Sy.x$) was 8.298 minutes.

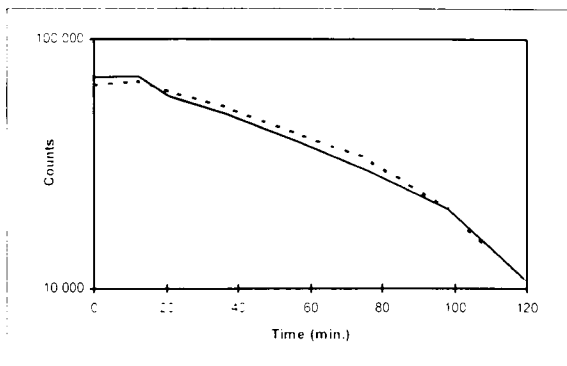


Figure 3. Two gastric emptying curve from one patient. Curve shown in solid line was generated from GM method and curve in dotted line from LAO method.

Figure 3. illustrates a sample of two gastric emptying curves from one patient. The curve shown in the solid line was generated from the GM method and the curve shown in a dotted line was from the LAO method. Both curves had almost identical aspects. Note the initial lag phase followed by the final declining phase.

Discussion

It is generally agreed that for accurate quantitative physiological studies, attenuation compensation of gastric emptying studies should be performed.^(5,8) The GM method is the accepted gold standard for compensating attenuation, but it requires acquisition of conjugate views. Obtaining both anterior and posterior images involves repositioning the patient for sequential images unless a dual-headed camera is used. The image processing is tedious because separate ROIs must be drawn for each image. The intermittent imaging limits the number of data points available for regression analysis compared to continuous acquisition and could affect the reliability of the results. And also, the lag phase of the solid gastric emptying time-activity curve is difficult to characterize when intermittent imaging is performed. A single view method, on the other hand, simplifies data collection and processing and permits continuous acquisition thus allowing for more accurate evaluation of the lag phase.

In seeking an attenuation compensation method that required the acquisition of images from a single view, other investigators have used either anterior⁽⁹⁾ or posterior⁽¹⁰⁾ views and corrected the depth by using the left lateral view or the LAO view.⁽⁶⁾ Roland et al.⁽⁹⁾ acquired continuous anterior views of a solid meal for 90 minutes, then at the end of that period an additional 270 μ Ci. of Tc-99m sulfur colloid in 150 ml of water was given and a 1-min left lateral view was then acquired for depth correction. Collins

et al⁽¹⁰⁾ used posterior views instead of anterior and performed the same method of depth correction. Fahey et al⁽⁶⁾ did a more complicated method using peak-to-scatter ratios with and without small intestinal activity for attenuation compensation. Although their results were promising, the methods of data analysis were complicated and some methods required two steps for acquisition.

In LAO projection, the activity within the stomach moves essentially parallel to the face of the Gamma camera, thus minimizing the variation of attenuation during the study. As we have shown in this study, even when no attenuation compensation had been applied, there was no statistical difference between the gastric emptying time and lag phase determined by the GM and the LAO methods in both groups of subjects ($p > 0.22$ and 0.12 respectively). Additionally, the correlation of gastric emptying time of both methods was good ($r = 0.957$) with a small standard error of estimation ($Sy.x = 8.298$).

We conclude that gastric emptying times determined by the LAO method is accurate and can be used for routine investigation. This method provides one-step continuous data acquisition, simple data analysis, no attenuation compensation requirement and more accurate lag phase determination.

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