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Editorial

Gastric emptying measured by ultrasonography

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A number of different methods have been used to estimate gastric emptying in humans, and all have their advantages and disadvantages. The method of choice will depend on whether solid or liquid meals are studied, the level of precision required, the degree of invasiveness that the subject or patient will tolerate, ethical considerations, and not at least the facilities available. Scintigraphy, with appropriate labelling of the test meal components and appropriate corrections applied, is considered so far the gold standard for measurement of gastric empty ing. However, its application is limited by the need to restrict exposure to ion ising radiation. Other methods are gastric aspiration techniques, radiography, ultrasonography, magnetic resonance imaging, epigastric impedance measurements, applied potential tomography, tracer methods (e.g. paracetamol), and breath tests. Regardless of the method used, the investigator must be aware of the limitations of the method in use, the large inter-individual variability and of the facto rs known to influence gastric emptying.

Ultrasonography is non-invasive, cheap, widely available, and can be repeatedly performed because of its safety. two- dimensional ultrasound has, for many year s, been widely used to assess gastric emptying rates[1-5], and good cor relation to radionuclide estimates of emptying rates have been detected[3,6]. In one study, ultrasound measurements of gastric emptying gave comparable sensitivity to scintigraphy in quantifying emptying of both low and high nutrien t liquids[7].

Ultrasound imaging of the proximal stomach is usually considered inappropriate due to the presence of gas-pockets and its relative inaccessibility close to the intra-thoracic cavity. However, an ultrasonographic method has been developed to overcome these problems and it demonstrated a moderate day-to day variation and low intra and interobserver error[8]. This method has been applied to study accommodation of the proximal stomach in patients with functional dys pepsia and the effect of different drugs on the stomach[9-12].

In addition to ordinary B-mode imaging, the movements of gastroduodenal contents and velocity curves of transpyloric flow can be synchronously visualised by du plex ultrasound, that is combination of Doppler measurement and B-mode imaging[13-16]. By use of duplex scanning, it was revealed that, in the fed st ate, a short gush of duodenogastric reflux normally precedes the peristaltic clo sure of the pylorus[14].

One of the latest advances in ultrasound tech nology is three-dimensional (3-D) imaging. An early system for acquisition and processing of 3-D ultrasound data was developed in an attempt to enhance the accuracy of volume computation of th e distal stomach[17]. Using a motor device, the transducer was tilted th rough an angle of 90°, capturing sequential Two-dimensional frames before the data set was transferred to a graphic workstation for final 3-D processing. This 3-D ultrasound system was validated both in vitro and in vivo, and yielded high accuracy and precision in volume estimation of abdominal organs[18,19]. This 3-D scanning system was also used to evaluate patients with fun ctional dyspepsia[20-22]. Despite the significant achievements with resp ect to accuracy in volume estimation and 3-D reconstruction of tissue and organ s, this 3-D system could only acquire a 90° fan-like data set from a pre-det ermined, single position of the transducer.

Random or free-hand acquisition of 3-D ultrasound data has been achieved by ut ilizing mechanical[23,24], acoustic[25-28], or electro magnetic [29,30] devices to locate the exact position and orientation of the tran sducer in space. To enable scanning of a large organ like the fluid-filled stom ach, a commercially available magnetometer-based position and orientation measurement (POM) device was chosen, which is relatively immune to metallic influence and electronic noise from the scanner. This system for magnetic scanhead tracking has been validated with respect to both its precision in locating specific points in space[30] and its accuracy in volume estimation[31,32]. In these studies, the sensor system worked well in scanning human organs, and high precision and accuracy were revealed in point location and volume estimation.

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In one study, 14 male volunteers were examined with 3-D ultrasound after ingest ion of a 500 mL soup meal up to 35 min postcibally[33]. The averag e half-emptying time of this meal was 22.1min±3.8min. Intragastric distribut ion of the meal, expressed as proximal/distal volume, varied on average from 3.6±2.1 (5 min postprandially) to 2.7±1.9 (30 min postprandially). This 3-D ultrasound system using magnetic scanhead tracking demonstrated excellent in vitro accuracy, calculated gastric emptying rates more precisely than by two-d imensional ultrasound, and enabled estimation of intragastric distribution of a soup meal in healthy subjects. The same 3-D imaging system was also used to eva luate gastric emptying and duodenogastric reflux stroke volumes using a digital colour Doppler ima ging model[34].

In conclusion, ultrasonography is a reliable and safe method to assess gastric emptying in humans. Ordinary two-dimensional ultrasound imaging can be supplied with Doppler analysis and 3-D scanning to obtain a higher level of information on pathophysiology of the stomach.

REFERENCES

1 Bateman DN, Whittingham TA. Measurement of gastric emptying by real-time ultrasound. *Gut,* 1982;23:524-527
2 Bolondi L, Bortolotti M, Santi V, Calletti T, Gaiani S, Labo G. Measurement of gastric emptying time by real time ultrasonography. *Gastroenterology,* 1985;89:752-759
3 Holt S, Cervantes J, Wilkinson AA, Wallace JH. Measurement of gastric emptying rate in humans by real-time ultrasound. *Gastroenterology,* 1986;90:918-923
4 Duan LP, Zheng ZT, Li YN. A study of gastric emptying in non-ulcer dyspepsiausing a new ultrasonographic method. *Scand J Gastroenterol,* 1993;28:355-360
5 Ricci R, Bontempo I, Corazziari E, La Bella A, Torsoli A. Real time ultrasonography of the gastric antrum. *Gut,* 1993;34: 173-176
6 Marzio L, Giacobbe A, Conoscitore P, Facciorusso D, Frusciante V, Modoni S. Evaluation of the use of ultrasonography in the study of liquid gastric emptying. *Am J Gastroenterol,* 1989;84: 496-500
7 Hveem K, Jones KL, Chatterton BE, Horowitz M. Scintigraphic measurement of gastric emptying and ultrasonographic assessment of antral area: relation to appetite. *Gut,* 1996;38: 816-821
8 Gilja OH, Hausken T, Odegaard S Berstad A. Monitoring postprandial size of the proximal stomach by ultrasonography. *J Ultrasound Med,* 1995;14:81-89
9 Gilja OH, Hausken T, Wilhelmsen I, Berstad A. Impaired accommodation of proximal stomach to a meal in functional dyspepsia. *Dig Dis Sci,* 1996;41:689-696
10 Gilja OH, Hausken T, Bang CJ, Berstad A. Effect of glyceryl trinitrate on gastric accommodation and symptoms in functional dyspepsia. *Dig Dis Sci,* 1997;42:2124-2131
11 Gilja OH, Hausken T, Odegaard S, Berstad A. Accommodation of the proximal stomach is fat dependent in functional dyspepsia. *Eur J Ultrasound,* 1996;4:S21
12 Vingerhagen S, Hausken T, Gilja OH, Berstad A. Influence of a 5HT1 receptor agonist (Sumatriptan) on gastric accommodation and initial transpyloric flow of a liquid meal examined by duplex sonography. *Gut,* 1997;41:A41
13 King PM, Adam RD, Pryde A, McDicken WN, Heading RC. Relationships of human antroduodenal motility and transpyloric fluid movement: non invasive observations with real-time ultrasound. *Gut,* 1984; 25:1384-1391
14 Hausken T, Odegaard S, Matre K, Berstad A. Antroduodenal motility and movements of luminal contents studied by duplex sonography. *Gastroenterology,* 1992;102:1583-1590
15 Hausken T, Gilja OH, Odegaard S, Berstad A. Flow across the human pylorus soon after ingestion of food, studied with duplex sonography. Effect of glyceryl trinitrate. *Scand J Gastroenterol,* 1998;33:484-490
16 Hausken T, Gilja OH, Undeland KA, Berstad A. Timing of postprandial dyspeptic symptoms and transpyloric passage of gastric contents. *Scand J Gastroenterol,* 1998;33:822-827
17 Thune N, Hausken T, Gilja OH, Matre K. A practical method for estimating enclosed volumes using 3D ultrasound. *Eur J Ultrasound,* 1996;3:83-92
18 Gilja OH, Thune N, Matre K, Hausken T, Odegaard S, Berstad A. In vitro evaluation of three-dimensional ultrasonography in volume estimation of abdominal organs. *Ultrasound Med Biol,* 1994;20:157-165
19 Gilja OH, Smievoll AI, Thune N, Matre K, Hausken T, Odegaard S, Berstad A. In vivo comparison of 3D ultrasonography and magnetic resonance imaging in volume estimation of human kidneys. *Ultrasound Med Biol,* 1995;21:25-32
20 Hausken T, Thune N, Matre K, Gilja OH, Odegaard S, Berstad A. Volume estimation of the gastric antrum and the gallbladder in patients with non-ulcer dyspepsia and erosive prepyloric changes, using three dimensional ultrasonography. *Neurogastroenterol Mot,* 1994;6:263-270
21 Gilja OH, Hausken T, Odegaard S, Berstad A. Three-dimensional ultrasonography of the gastric antrum in patients with functional dyspepsia. *Scand J Gastroenterol,* 1996;31:847-855
22 Berstad A, Hausken T, Gilja OH, Thune N, Matre K, Odegaard S. Volume measurement of gastric antrum by 3 D ultrasonography and flow measurements through the pylorus by duplex technique. *Dig Dis Sci,* 1994;39:97-100
23 Dekker DL, Piziali RL, Dong EJr. A system for ultrasonically imaging the human heart in three dimensions. *Comput Biomed Res,* 1974;7:544-553
24 Nikravesh PE, Skorton DJ, Chandran KB, Attarwala YM, Pandian N, Kerber RE. Computerized three dimensional finite element reconstruction of the left ventricle from cross-sectional echocardiograms. *Ultrason Imaging,* 1984;6:48-59
25 Moritz WE, Shreve PL, Mace LE. Analysis of an ultrasonic spatial locating system. *IEEE Trans Instrum Meas,* 1976;25:43-50
26 Brinkley JF, Muramatsu SK, McCallum WD, Popp RL. In vitro evaluation of an ultrasonic three-dimensional imaging and volume system. *Ultrason Imaging,* 1982;4:126-139
27 Handschumacher MD, Lethor JP, Siu SC, Mele D, Rivera JM, Picard MH, Weyman AE, Levine RA. A new integrated system for three-dimensional echocardiographic reconstruction: Development and validation for ventricular volume with applicati on in human subjects. *J Am Coll Cardiol,* 1993;21:743-753
28 Levine RA, Handschumacher MD, Sanfilippo AJ, Hagege AA, Harrigan P, Marshall JE, Weyman AE. Three-dimensional echocardiographic reconstruction of the mitral valve, with implications for the diagnosis of mitral valve prolapse. *Circulation,* 1989;80:589-598
29 Kelly IM, Gardener JE, Brett AD, Richards R, Lees WR. Three-dimensional US of the fetus. Work in progress. *Radiology,* 1994; 192:253-259
30 Detmer PR, Bashein G, Hodges TC, Beach KW, Filer EP, Burns DH, Strandness JrDE.3D ultrasonic image feature localization based on magnetic scanhead tracking:In vitro calibration and validation. *Ultrasound Med Biol,* 1994;20:923-936
31 Hodges TC, Detmer PR, Burns DH, Beach KW, Strandness JrDE. Ultrasonic three-dimensional reconstruction: In vitro and in vivo volume and area measu rement. *Ultrasound Med Biol,* 1994;20:719-729
32 Gilja OH, Hausken T, Olafsson S. In vitro evaluation of three-dimensional ultrasonography based on magnetic scanhead tracking. *Ultrasound Med Biol,* 1998;24:1161-1167
33 Gilja OH, Detmer PR, Jong JM, Leotta DF, Li XN, Beach KW, Martin R, Strandness DEJ. Intragastric distribution and gastric emptying assessed by three-dimensional ultrasonography. *Gastroenterology,* 1997;113:38-49
34 Hausken T, Li XN, Goldman B. Quantification of gastric emptying and duodenogastric reflux stroke volumes using three-dimensional guided digital color Doppler Imaging. *Eur J Ultrasound,* 1998;7:(S1)3421

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