Simultaneous monitoring of gallbladder and gastric emptying by EPI

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Introduction

Since the early 80s [1-3] up to date [4-11] there has been constant interest in assessing gallbladder and gastric emptying simultaneously, as this will provide an insight into the physiology of the gallbladder contraction and its co-ordination with gastric emptying and the delivery of nutrients to the duodenum in response to a meal [1-3]. This can also aid studies of gut hormone peptides signalling [9,11] as well as of abnormalities in diseases such as diabetes and hepatitis [4,10], and of the action of pharmacological interventions [5,8]. Such investigations have been conducted using gamma scintigraphy techniques [1,2,4,9], ultrasound [10], a combination of both ultrasound and scintigraphy [7] or ultrasound and the breath hydrogen test [3,5]. However, such techniques suffer from known limitations such as poor spatial resolution, lack of three-dimensional capability or use of radioactive materials.

Recently, MRI has been shown to be able to measure the emptying of the gallbladder accurately, non invasively and with high spatial resolution [12,13]. It has also been shown that MRI can measure gastric emptying. In this study we aimed to assess for the first time the potential of EPI for the simultaneous assessment of gallbladder and gastric emptying, with a view of developing a simple method that could improve upon and thus substitute some of the ultrasound and scintigraphic techniques mentioned above.

Materials and Methods

Eight healthy subjects ingested 500 ml of a liquid test meal containing 15% olive oil (stabilised with Tween 60 surfactant and designed to be stable with low pH, as found in the gastric environment) and flavouring. Before ingestion, immediately after ingestion and every 20 min for 3 hours thereafter, a rapid MBEST EPI (effective echo time T_E=40 ms) multi-slice set was acquired across the whole abdomen, to encompass both the gallbladder and the gastric lumen. A dedicated, whole-body, 0.5 T, EPI scanner, equipped with actively shielded gradients and a 50 cm ∅ bird-cage coil ($3.5\times2.5\times10$ mm^3 resolution, 128×128 matrix) was used. This protocol was approved by the local Ethics Committee. Subjects gave informed written consent and were kept sitting upright in between scanning. Images were processed by manually drawing regions of interest on Analyze (Mayo Foundation, MN).

After a meal, the gallbladder volume showed both an emptying and a delayed refilling phase. We fitted the data to an empirical model:

$$V(t)=V_1\,e^{-\frac{t}{D_1}}+V_2\,e^{-\left(\frac{t-\tau}{D_2}\right)^2} \qquad (1)$$

where V_1 and V_2 are the maximum volume reached in each phase and D_1 and D_2 are their time constants. τ represents the time delay of the second component's peak. Data are presented as mean ± SEM.

Results

Due to the intrinsic T_2* weighting of EPI, the bile in the gallbladder and the test meal in the stomach appeared very bright in the images, aiding localisation and region of interest analysis. The average gallbladder emptying curve is shown in Figure 1. The solid line is the line of best fit to the model described above. The mean fasted gallbladder volume was 25 ± 4 ml, comparable to previously published MRI and ultrasound values ([13] and references therein). Figure 2 shows the average gastric emptying curve. Gastric emptying was linear (R^2=0.99), as expected for a test meal rich in fat. The exponential (R^2=0.98) co-ordination of gallbladder and gastric emptying is shown in Figure 3, where gallbladder volume values are plotted against gastric volume values at corresponding time points for the first 90 min (i.e. before the gallbladder started re-filling).

Conclusion

This study shows the potential of EPI to monitor simultaneously and non-invasively the emptying of the gallbladder and of the gastric lumen. No enhancing agents are needed. The maximum and minimum gallbladder volumes allow easy estimates of gallbladder contraction [12]. Importantly, it will be possible to correlate gallbladder emptying with gut signalling peptides and calories output to the duodenum (by knowing meal energy density, dilution [14] and gastric emptying rate) with and without the action of drugs. An EPI multi-slice scan across the abdomen takes only a few seconds to perform, and so several subjects could be interleaved within the same experimental session saving costs and machine time. Semi-automation of the volume measurements could be aided by increasing the T_2 weighting of the EPI module. The model yielded a good data fit as shown in Fig. 1. The model could be refined when more data will be available. In particular it would be interesting to investigate the possible presence of two gallbladder emptying components (fast and slow) that have previously been reported [3].

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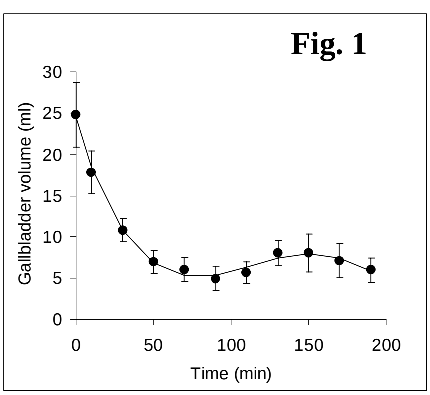
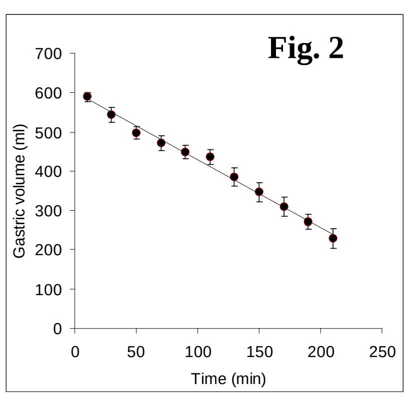
References: **1.** Baxter *et al.* Gut 26: 342, 1985. **2.** Fisher *et al.* Dig Dis Sci 32: 1337, 1987. **3.** Lawson *et al.* Gastroenterol 85: 866, 1983. **4.** Annese *et al.* J Clin Gastroenterol 29: 171, 1999. **5.** Goerg *et al.* Aliment Pharm Ther 17: 445, 2003. **6.** Degen *et al.* Gastroenterol 118: 2049, 2000. **7.** Degen *et al.* Gastroenterol 120: 361, 2001. **8.** Von Kiedrowski *et al.* Dig Dis Sci 46: 939, 2001. **9.** Hidalgo *et al.* Neurogastroenterol Mot 14: 519, 2002. **10.** Portincasa *et al.* Eur J Clin Inv 31: 617, 2001. **11.** Mollen *et al.* Digestion 62: 185, 2000. **12.** Vyas *et al.* JMRI 15: 75, 2002. **13.** Inoue *et al.* JMRI 18: 196, 2003. **14.** Marciani *et al.* Am J Phisiol 280: G1227, 2001.





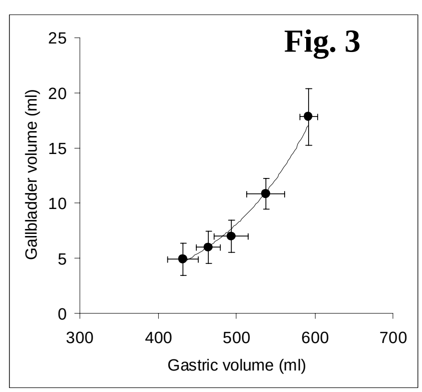


Fig. 1: The average gallbladder volumes plotted versus time of acquisition. t=0 is before ingestion of the test meal, t=10 min is immediately after the test meal. The solid line shows the best fit of the data to the model described by Equation (1). **Fig. 2:** The average gastric volumes plotted versus time of acquisition. The solid line shows the linear fit to the data (R^2=0.99). **Fig. 3:** Gallbladder volume values plotted against gastric volume values at corresponding time points for the first 90 min (i.e. before the gallbladder started re-filling). Co-ordination of gallbladder and gastric emptying in this case is exponential (R^2=0.98).