Corresponding author:
Dr K.L. Dorrington
Associate Professor of Physiology & Honorary Consultant
Department of Physiology, Anatomy & Genetics,
Parks Road, Oxford, OX1 3PT
Tel: 01865-272486
Fax: 01865-272488
Email: keith.dorrington@dpag.ox.ac.uk

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Starvation before surgery: is our practice based on evidence?

Georgina Rudge Wilson MBBS BSc FRCA[1] & Keith Leonard Dorrington MA DPhil DM BCh FRCA[2,3]

1 *Core Trainee in Anaesthetics, John Radcliffe Hospital, Oxford, UK.*

2 Associate Professor of Physiology, Department of Physiology, Anatomy & Genetics, University of Oxford

3 Honorary Consultant, Nuffield Department of Anaesthetics, John Radcliffe Hospital, Oxford, UK.

Short running head: Pre-operative starvation

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Key Points

● Adults attending for elective surgery continue to be starved excessively.

● Studies of stomach emptying show that 6 h are sufficient for solid meals of moderate size.

● Studies after liquid alone show an exponential course over time, with a half-time ($T_{½}$) that depends upon calorific content. For tea with milk $T_{½}$ is ~25 min; for water $T_{½}$ is ~15 min.

● Current ESA guidelines recommend starvation times of 6 h from ‘solid food’ and 2 h from liquids, which may now include tea or coffee with 20% milk.

● Aspiration or airway obstruction from food can occur even following prolonged starvation.

Summary

Excessive starvation before surgery currently brings much misery to patients even though it is widely accepted amongst anaesthetists that adult patients should be starved of food for six hours and able to drink ‘clear fluids’ for up to two hours before surgery. There is disagreement about what fluids should be permitted, and recent European guidelines permitting up to 20% milk in drinks such as tea and coffee have not met with favour in some centres. We review studies on the rates of emptying of solid and liquid components of stomach contents, drawing attention to different methods that have been used to study them, and some physiological factors that have been found to contribute to delays in emptying. We remind readers of the origin of Mendelson’s Syndrome, the danger of particulate matter in the stomach, and the historical focus on liquid volumes and pH in the stomach of patients presenting for anaesthesia. The major recent American and European guidelines on pre-operative starvation are discussed along with the widespread reluctance amongst staff and patients themselves to adopt recommended regimes of starvation.

Introduction

The misery articulated by patients denied their morning cuppa before coming to hospital for surgery is long-established and apparently ineradicable. A recent (Feb 2016) small audit of 44 adult patients admitted for elective surgery in five specialties in Oxford found that they had been denied (or denied themselves) drink for an average of 9 hours (range 2-24 h) and food for 14 hours (range 6-22 h) before being anaesthetized. These data are similar to those acquired three years earlier in the same trust in 190 elective patients in 17 surgical specialties, which showed that 70% of patients were fasted over twice the recommended length of time for both food (6 h) and drink (2 h), and 97% starved longer than required (Dr Medha Varanese, personal communication). This aspect of the pre-operative care of patients does not bring us credit, even though its occurrence appears widespread and resistant to efforts aimed at change[1-4].

By way of contrast it is salutary to remind ourselves that aspiration of stomach contents has historically been regarded as a major life-threatening problem associated with anaesthesia. In the USA in 1951, a study of 300 surgical patients found regurgitation of stomach contents in 26% and aspiration of such material into the lungs in 16%; frank vomiting occurred peri-operatively in another 8% of patients. Morbidity and mortality figures for the series were not given[5]. In that study, endotracheal tubes, where present (in 72% of cases), had no cuffs, and little influence on whether regurgitated stomach contents found their way into the trachea. In the UK, in 1956, a report of 598 deaths associated with anaesthesia found 110 (18%) to be associated with either regurgitation or vomiting; many of these were cases of emergency abdominal surgery[6].

What perhaps is more difficult to judge from the early literature is the extent to which individual episodes of regurgitation and aspiration carried a high risk of serious injury or death. The classic paper in the field, that of Mendelson in 1946, reported 66 cases of

aspiration during obstetric anaesthesia, an incidence of 0.15% of 44,016 pregnancies in New York[7]. Two deaths occurred, each from solid material obstructing the airway. One interpretation of this early study might be that, despite the aspiration leading to cyanosis, tachycardia & dyspnoea in most of the 66 cases, the only deaths occurring were from suffocation by solids and that aspiration of liquid into the airway was much less harmful. Nevertheless, the frequency of reports of disasters associated with aspiration over many years rightly makes avoidance of this complication of anaesthesia a huge priority for every patient anaesthetized.

Our aim in this educational piece is to focus on the evidence underlying the starvation of adult patients for elective surgery whilst reminding the reader of some of the physiological factors associated with delayed stomach emptying and some of the published recommendations.

Stomach emptying after meals containing solid food

Mendelson reported that the two patients in his series who died from suffocation brought about by solid food had ingested their meals eight and six hours before the attempt to anaesthetize them[7]. These obstetric patients are a reminder that in some circumstances the stomach retains undigested food for a very long period of time.

Physiological stomach emptying after meals of different sizes was studied thoroughly by Moore et al in 1981 using separate isotopes for the solid and liquid elements of meals[8]. Figure 1 shows their data for the retention of food (and liquid) in the stomachs of ten healthy males eating 14 meals to satiety over 30 min following a 20-h period of starvation. We note that 1.7 kg of food and drink was consumed, in approximately equal quantities, and that the solid food component was removed approximately linearly over time with a time to half emptying ($T_{½}$) of 277 min (~4.5 h). These data, if extrapolated from 5.5 h, suggest that a

traditional pre-operative 6-h fast following such a large meal may leave approximately 30% of the solid component in the stomach.

Moore et al compared their findings for the large meal with those for smaller meals of total mass 900 g and 300 g, both half solid and half liquid, and found striking differences with $T_{½}$ respectively equal to 146 and 77 min (Table 1). For these smaller meals, extrapolation of their measurements suggests that no solid food would remain at the traditional 6-h starvation time. A helpful way of thinking of the rate at which solids leave the stomach is that a wide range of intermediate meal sizes (~150-450 g of solids) all empty at a fairly constant rate in terms of grams per minute in the approximate range 1.0-1.5 g/min in a linear manner. With such 'zero-order' elimination kinetic the use of a half-life ($T_{½}$) can be misleading, unless it is clear that it is measured from the time of meal consumption.

The 'theatre breakfast' has been of interest. Cornflakes with sugar and milk were followed by Heading et al, who found a near-linear elimination of the solid component with $T_{½}$ = 102 min (Table 1)[9]. Miller et al, writing from a setting in which the standard fast after a small breakfast was 2-4 h, found that buttered toast with tea or coffee and milk left a residual volume in the stomach at ~3.5 h that was not significantly different from the volume after a fast of ~12 h, in both cases ~10 ml (Table 1)[10]. In this case direct sampling of liquid from the stomach by tube was used following induction, a technique recognized as incapable of retrieving sizeable solid lumps of food.

The use of separate isotopes to label solid and liquid food has made it possible to identify the stomach emptying of these components concurrently. As shown for the example in Figure 1, liquid is more speedily removed from the stomach and the emptying tends to take a more exponential course. As for the solid component, $T_{½}$ is greater the larger the volume of liquid present in such a meal[8].

Newer techniques using ultrasound or magnetic resonance imaging have not been able to follow separately the emptying of solid and liquid components of a normal mixed meal but have tended to confirm the findings of the earlier studies for separate solid and liquid meals, namely the fairly linear elimination of solid foods and the more exponential elimination of liquids[11-13]. Table 1 lists findings from several studies of stomach emptying after meals containing solids. Table 2 summarizes the influences of several factors on the physiological rates of emptying of solid and liquid components of meals, including meal size, time of day and age.

Stomach emptying after meals containing only liquids

Several studies are available from which we can assess the speed of emptying of the stomach following liquid intake. Figure 2 shows an example time-course of stomach emptying from a study of 11 healthy volunteers following a 300-ml drink of beef extract in water[13]. Two measurement techniques gave indistinguishable values for $T_{½}$ at 20 min. The traditional term 'clear fluids' seems to have been introduced to encourage exclusion of milk. To what extent a beef-extract drink can be regarded as 'clear' will be a subjective judgement. Concern to permit patients both to relieve their sense of thirst and to have some choice with regard to what to drink led Hutchinson et al to compare the effects a cup (150 ml) of either coffee or orange juice taken 2-3 h pre-operatively with an overnight fast on stomach contents and pH (see Table 3)[14]. No significant differences were found. Of relevance is that coffee has been found in elsewhere not to affect gastric emptying of a liquid meal in healthy volunteers[15, 16].

In a partner study to that of Hutchinson et al, the addition of ranitidine to drinks of coffee or orange juice was found to increase stomach pH substantially (Table 3) and reduce the proportion of patients from about half to ~7% who had the combination of content volume >25 ml plus pH < 2.5 that had established itself as a level of concern at that time[17, 18].

A further study from the Calgary group, without ranitidine, found in 211 patients that the time of consumption of a 150-ml drink, in this case of tea, coffee, apple juice, or water, in the time range 3-8 h and beyond, had no effect on volume or pH[19]. Though these papers from Canada did not mention milk, subsequent enquiry showed that some patients were permitted milk in their tea or coffee[20].

A study from Norway examining volumes of water from 20 to 450 ml ingested with diazepam 1.5 h before induction of anaesthesia found no effect of drink volume on stomach contents or pH (Table 3), and therefore made a case for reducing the time between a modest intake of water and surgery to 1-2 h in healthy patients, but made the observation that the larger volumes often led to an inconvenient diuresis shortly before surgery was due to commence[21].

A period followed these studies in which the uptake and subsequent physiological effects of a wide variety of drinks containing carbohydrates, amino acids, and peptides have been studied using different modalities[22-28]. Potential indications for the use of such special solutions have recently been reviewed in this Journal by Fawcett and Ljungqvist (ref). The benefits of maintaining pre-operative nutrition may include some protection against surgical trauma in terms of metabolic status, cardiac function, and psychosomatic wellbeing[27]. The more widespread application of these potentially expensive potions is limited by availability and the fact that patients may have to be given them to take home for preoperative use.

Returning to the more universally available liquids, a recent study asked ‘Does adding milk to tea delay gastric emptying’? Hillyard et al used both the paracetamol absorption technique and ultrasound to compare stomach emptying after 300 ml of black tea or the more traditional ‘cuppa’ consisting of 250 ml of tea and 50 ml of (full-fat, 4%) milk (Table 3). No significant difference was found in either measure; $T_{½}$ measured by ultrasound was close to 23 min. An expectation that milk might increase the emptying time of a drink recently led

Okabe et al to examine the hypothesis that it is the calorific value of a drink, rather than its volume, that determines the rate with which it leaves the stomach[29]. Usefully their study used commonly available milk, orange juice, and water (as well as 'gum syrup' with which to manipulate calorific content). Their results are shown in Figure 3.

Several striking features are contained within these data. First, we see that a drink of 500 ml of water is largely absorbed within 30 min and no longer detectable at 60 min, consistent with the findings of other similar experiments[24, 30]. Second, 20% of a large (500-ml) intake of milk appears to remain in the stomach two hours after it is drunk, whereas a smaller dose of milk (330 ml) is removed in 120 min. Third, these data support the hypothesis that it is the energy content of the drink that determines the $T_{½}$ of the exponential absorption. Interestingly, the pairs of drinks of similar calorific value had very different osmolarities, suggesting that this property of a liquid in the stomach does not play a major role in its rate of elimination. This in turn suggests that absorption across the wall of the stomach is unlikely to be a major route of exit from the stomach.

Table 3 gives the findings of several studies on gastric emptying after the intake of liquids alone.

Published guidelines regarding pre-operative starvation

Modern guidelines for pre-operative starvation can be regarded as similar to that given by Lord Lister in 1882: "While it is desirable that there should be no solid matter in the stomach when chloroform is administered, it will be found very salutary to give a cup of tea or beef-tea about two hours previously"[19]. Of the many guidelines from recent years those from 2011 of the European Society of Anaesthesiology (ESA)[20] and the American Society of Anesthesiologists (ASA)[31] are influential and typical. Perhaps the Rolls-Royce of earlier

systematic reviews is the 156-page evaluation by Brady et al in the Cochrane Database of Systematic Reviews of 2003[32].

The Cochrane review of 2003 identified 38 relevant randomized controlled comparisons made within 22 trials worldwide and reviewed pre-operative fasting and the association with peri-operative complications[32]. It was undertaken at a time when 'nil by mouth from midnight' was still in favour. Under 'implications for practice' the authors wrote of their findings: "There was no evidence that participants given fluids two to three hours preoperatively were at an increased risk of aspiration/regurgitation (as measured by their gastric volume and pH) than participants who had followed a standard fast (nil by mouth from midnight). Unsurprisingly, a drink during the preoperative period was noted to be beneficial in terms of patients' experience of thirst. In addition, there was no indication that participants given fluids up to 90 minutes before induction of anaesthesia were at increased risk of regurgitation/aspiration but this was based on very small numbers of participants".

The ASA recommendation for fluid starvation in healthy adults undergoing elective surgery is as follows: "It is appropriate to fast from intake of clear fluids at least 2 h before elective procedures requiring general anesthesia, regional anesthesia, or sedation/analgesia (i.e. requiring monitored anesthesia care). Examples of clear liquids include, but are not limited to, water, fruit juices without pulp, carbonated beverages, clear tea and black coffee. These liquids should not include alcohol. The volume of liquid ingested is less important than the type of liquid ingested"[31].

With regard to starvation from food, the ASA guidelines for these patients can be summarized as: 6 h from a 'light meal or non-human milk' and 8 h or more from a meal containing 'fried or fatty foods or meat'. A 'light meal' is said typically to consist of 'toast and clear fluids'. Interestingly, no routine preoperative use is recommended by the ASA for any pharmacological agents relating to the gastrointestinal (GI) system, including GI

stimulants (e.g. metoclopramide), H_2-receptor blockers (e.g. ranitidine), proton pump inhibitors (e.g. omeprazole), antacids (e.g. sodium citrate), antiemetics (e.g. ondansetron), or anticholinergics (e.g. glycopyrrolate). Dexamethasone is not mentioned.

European recommendations have shown a degree of liberalization. The Scandinavian guidelines from 2005 included the recommendation of a drink of 150 ml of water (with oral medication) up to 1 h before anaesthesia[33]. The ESA guidelines encourage fluids up to 2 h before elective surgery but present a marked change on the subject of milk[20]: in relation to what constitutes a clear fluid "all but one member of the guidelines group consider that tea or coffee with milk added (up to about one fifth of the total volume) are still clear fluids". Since such drinks are clearly not 'clear' in the OED sense of being 'unclouded' or 'transparent', these recommendations now lack a suitable generic term for what they regard as safe drinks. Given the potential importance to many of our patients of allowing tea and coffee with up to 20% milk, it is perhaps worth noting the approach taken by the guideline group: "In reaching consensus, particular emphasis was placed upon the level of evidence, ethical aspects, patient preferences, clinical relevance, risk/benefit ratios and degree of applicability. For example, a pragmatic solution to an acceptable amount of milk in tea or coffee was agreed based upon the unpublished experience accumulated by several members of the group over many years"[20]. The more senior of the current authors is reminded of the consultant who taught him as a junior over several years to use the drug chart to prescribe elective Caesarean patients their premedication with a cup of tea 1-2 hours before surgery. At least with regard to non-pregnant patients, the recent evidence from studies involving milk add experimental evidence to what is described above as a pragmatic solution[29, 34].

In relation to food, the ESA guidelines are simple: "solid food should be prohibited for 6 h before elective surgery in adults". It is interesting that the caution suggested in the ASA guidelines regarding meal size is absent here. Recent studies have not examined this

matter, but we have seen from the 1981 study depicted in Figure 1 that about 30% of the solid material from a heavy meal can still be present in the stomach after 6 h. As with the ASA recommendations, no routine preoperative use is recommended of metoclopramide, antacids or H_2-antagonists before elective surgery in non-obstetric patients. The absence of a recommendation about antiemetics in these guidelines (in contrast to those of the ASA) may be seen as recognition of their proven value in preventing post-operative nausea and vomiting.

Summary

Even focused institutional efforts to reduce starvation times to recommended values appear to be minimally effective[1, 3]. This may not be the place to address the multifactorial literature about entrenched clinical, nursing, managerial & psychological factors that still tend to extend the actual durations of pre-operative starvation to an often inhumane extent despite the increasing bureaucratic protocolization of the 'patient pathway' with detailed 'care plans' and checklists. Helpful discussions of difficulties in achieving adherence to guidelines can be found in papers by Bosse *et al* [35] and Crenshaw[2]. Anaesthetists will be familiar with the difficulty of estimating in advance the actual time of surgery in most patients, but perhaps this should not prevent us from giving them, ourselves, and nursing staff an estimate to work towards, and being determined to try our best not to starve them for longer than is necessary. Perhaps this is one example of where 'putting ourselves in the patient's shoes' would help prevent us starving nearly all our patients for longer than necessary in the manner referred to earlier in a recent survey.

The evidence we have reviewed reminds us that no patient is excluded from a risk of aspiration of stomach contents, for however long the patient is starved. Large meals have been shown to leave a substantial proportion of food in the stomach even after a 6-h fast

(Figure 1). Yet recent evidence has shown that drinks that patients prefer, such as tea with milk and juice, can be regarded at safe up to 1-2 h before surgery in elective patients (Table 3), with 2 h perhaps remaining the best soft target period for practical purposes. For water, 1 h appears entirely satisfactory, with or without medication (Figure 3).

Table 1

Gastric emptying after meals containing solids

Meal/Drink	Reference	$T_{1/2}$ (SEM) min	Time to assay min	Rate of emptying g/min	Residual pH	Residual volume, ml	Comment	Participant number
Cornflakes, sugar (35 g) & milk (150 ml)	Heading et al (1976)[9]	102(20) solids 33(5) liquid		0.2				9 adults
Filling meal (1692 g) ~half liquid	Moore et al (1981)[8]	277 (44) solids 178 (22) liquid		1.9			See Fig. 1 near linear emptying of solids	10 males (25-43 y)
900-g meal half liquid	Moore et al (1981)[8]	146 (26) solids 81(12) liquid		1.5			near linear emptying of solids	10 males (25-43 y)
300-g meal half liquid	Moore et al (1981)[8]	77(5) solids 40(4) liquid		0.9			near linear emptying of solids	10 males (25-43 y)
Buttered toast with tea/coffee with milk	Miller et al (1983)[10]		199		1.9* (median)	10.9†	study of 4-h fast from light meal	10 females
No intake for 12 h	Miller et al (1983)[10]		714		6.3* (median)	8.8†	study of 4-h fast from light meal (control)	11 females
Small (300 g) meal, half liquid	Goo et al (1987)[36]	64.8 (6.4) AM		1.1			near linear emptying of solids	16 males (21-42 y)
Small (300 g) meal, half liquid	Goo et al (1987)[36]	97.1 (11.5) PM (50% increase)		0.9			near linear emptying of solids	16 males (21-42 y)

Table 1. The results of studies examining stomach emptying in healthy volunteers of meals containing solids. $T_{1/2}$ refers to the time to half emptying of the stomach and SEM to standard error of the mean. * & † no significant differences found.

Table 2

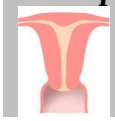
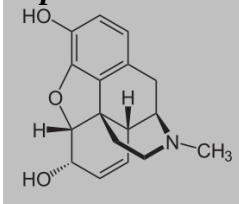
Factor	Observation	Study group
Time of day 	Solid (but not liquid) meal emptying was slower (by ~50%) in the evening (8pm) than the morning (8am)[36]	16 healthy males (21-42 y)
Size of meal 	Solid & liquid meals showed $T_{1/2}$ that increased greatly (~x4) with meal mass[8]. See Table 1.	10 healthy males (25-43 y)
Female gender 	Following a 300-g meal, for females $T_{1/2}$ for solid and liquids were 92 and 54 min respectively; for males the figures were 60 and 30 min[37].	15 healthy males (21-53 y) and females (23-44 y)
Age 	The liquid (but not solid) half of a 900-g meal was absorbed more slowly in older than younger men. Retention at 120 min was 40% in older, and 25% in younger, men[38].	10 young males (24-51 y) & 10 aged males (71-88 y)
Menstrual cycle luteal phase 	Solid (but not liquid) meal emptying was slower (by 36%) in the luteal phase than the follicular phase[39]	7 normally-menstruating females (33-44 y)
Pregnancy 	Following 750 ml of water, $T_{1/2}$ was 11 min in pregnancy and 18 min in controls, with respective emptying times 75 min and 120 min[40]. In 11 labouring women, emptying was prolonged.	11 healthy pregnant Jamaican women (>34 weeks) were compared with 11 healthy non-pregnant women and 11 women in labour.
Opiates 	Morphine (7.5 mg iv) ~halved the rate of gastric emptying after a small meal of orange juice with an egg sandwich. (Interestingly, Naloxone (2 mg iv) had a similar effect.)[41] Even lower doses of morphine may have a substantial effect[42]	6 healthy volunteers (23-32 y)

Table 2. Factors found by some studies to be associated with a delay in stomach emptying.

Table 3

Gastric emptying after intake of liquid only

Meal/Drink	Reference	Liquid Volume (pH) ml	$T_{1/2}$ (SEM) min	Time to assay, min	Residual pH	Residual volume, ml	Comment	Participant number (ages)
Citrus pectin with sucrose & water	Hunt et al 1951[43]	750 (6.5)	21.8 (1.3)	0-120			Exponential emptying	21 (21-50 y)
Beef extract in water	Holt et al 1986[13]	300	21(3.0) †	0-60			Exponential emptying	11 (25-72 y)
Water	Sutherland et al 1987[44]	160		141	2.1	20.6		25 (18-60 y)
Water with Ranitidine 150 mg	Sutherland et al 1987[44]	160		145	6.7	10.0		25 (18-60 y)
No intake	Sutherland et al 1987[44]	10 (indicator)		151	1.7	29.9		25 (18-60 y)
Ranitidine 150 mg	Sutherland et al 1987[44]	10 (indicator)		138	6.3	9.7		25 (18-60 y)
Coffee	Hutchinson et al 1988[14]	150		151	2.2	24.5		50 (18-60 y)
Orange juice	Hutchinson et al 1988[14]	150		163	2.0	23.7		50 (18-60 y)
No intake	Hutchinson et al 1988[14]	0		153	2.0	23.2		50 (18-60 y)
Coffee with Ranitidine	Maltby et al 1988[17]	150		161	5.7	14.3		50 (18-60 y)
Orange juice with Ranitidine	Maltby et al 1988[17]	150		142	5.4	14.8		50 (18-60 y)
Ranitidine 150 mg	Maltby et al 1988[17]	0		159	6.2	9.7		50 (18-60 y)
Tea, coffee, apple juice or water	Scarr et al 1989[19]	150		180-48ϕ	~2	~26	No effect of starvation time on pH or volume	154 (mean age ~34 y)
Water	Soreide et al 1993[21]	20		94	1.9	31		25 (20-43 y)
Water	Soreide et al 1993[21]	150		88	1.5	23		25 (19-47 y)
Water	Soreide et al 1993[21]	450		89	2.0	23		25 (23-44 y)
Tea (black)	Hillyard et al 2014[34]	300	22.7	60		As pre-drink		9 (30-36 y)
Water	Greenfield et al 1996[45]	330		117	2.0	12.5	Endoscopy patients	44 (mean 46 y)
No intake	Greenfield et al 1996[45]	0		overnight fast	2.0	10.0	Endoscopy patients	44 (mean 48 y)

'Clear fluids'	Philips et al 1993[46]	388 (50-1200; 30-ml premed in 70%)		120‡	2.6	21	50 (>18 y)
No intake	Philips et al 1993[46]	30 (premed in 44%)		120‡	2.3	19	50 (>18 y)
Tea with Milk (4%)	Hillyard et al 2014[34]	250 + 50	23.6	60		As pre-drink	9 (30-36 y)
Water	Okabe et al* 2015[29]	500		60		As pre-drink	8 (median 27 y)

Table 3. The results of studies examining stomach emptying in healthy volunteers, or patients attending for elective surgery or endoscopy. $T_{1/2}$ refers to the time to half emptying of the stomach and SEM to standard error of the mean. †Two different methods of measurement were used (ultrasound and scintigraphy) giving no significant difference (see Figure 2). ϕ Three groups with different fasting times between 180 and 480 min were studied (and one for longer); the data here are approximate means for these three groups. ‡ Patients drank clear fluids freely between 6 and 2 hours pre-operatively; controls (no intake) were starved of liquid intake for 12.9 h. Premed (30 ml with temazepam 10-20 mg) was given 2 h pre-operatively to some patients. *See Figure 3 for other data from this study.

Legends to figures

Figure 1

Time-course over 5.5 h of the percentage retention in the stomach of a large meal. Ten healthy males (25-43 y) consumed a total of 14 meals, each over 30 min after a 20-hr solid-food fast. The meal was self-selected from a wide range of food and drink. The average meal weight was 1692 g; the liquid-solid ratio was 1.10; mean kcal consumption was 1945 provided by 34% carbohydrate, 21% protein, and 45% fat. Figure drawn from the data of Moore et al[8]. Error bars show SEM.

Figure 2

Time-course over 60 min of the percentage residual volume/radioactivity in the stomach after a 300-ml intake of beef extract (Oxo) in water. Eleven healthy volunteers (5 men, 6 women; 25-72 y) drank the liquid over 3-5 min after an 8-h fast. Solid line: data obtained by ultrasound. Dashed line: data obtained by scintigraphy using 250 μCi of ^{99m}Tc-sulphur colloid. Figure modified from[13]. Error bars show SD.

Figure 3

Time course over 120 min of the gastric volume after ingestion of one of five different drinks each of 500 ml volume. The data are changes from a pre-drink baseline. Eight healthy male volunteers drank the liquid after a 6-h fast from food and a 2-h fast from clear fluids. The drinks were designed to be in three groups of differing calorific value: closed squares, milk 500 ml, 330 kcal; open squares orange 450 ml with gum syrup 50 ml, 330 kcal; closed circles orange juice 500 ml, 220 kcal; open circles milk 330 ml with water 170 ml, 220 kcal; open triangles water 500 ml, 0 kcal. Figure modified from[29]. Error bars show SD.

Figure 1

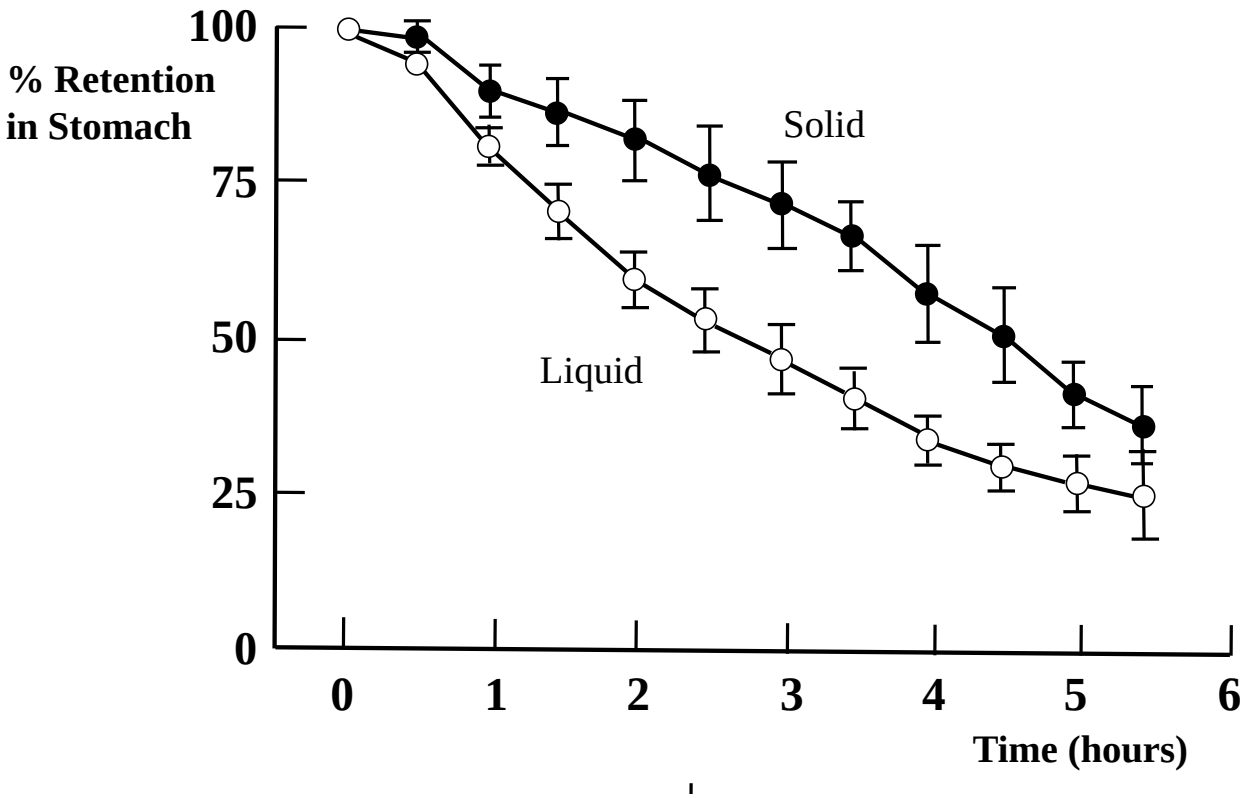

100
% Retention
in Stomach
75
50
25
0
Solid
Liquid
0
1
2
3
4
5
6
Time (hours)

Figure 2

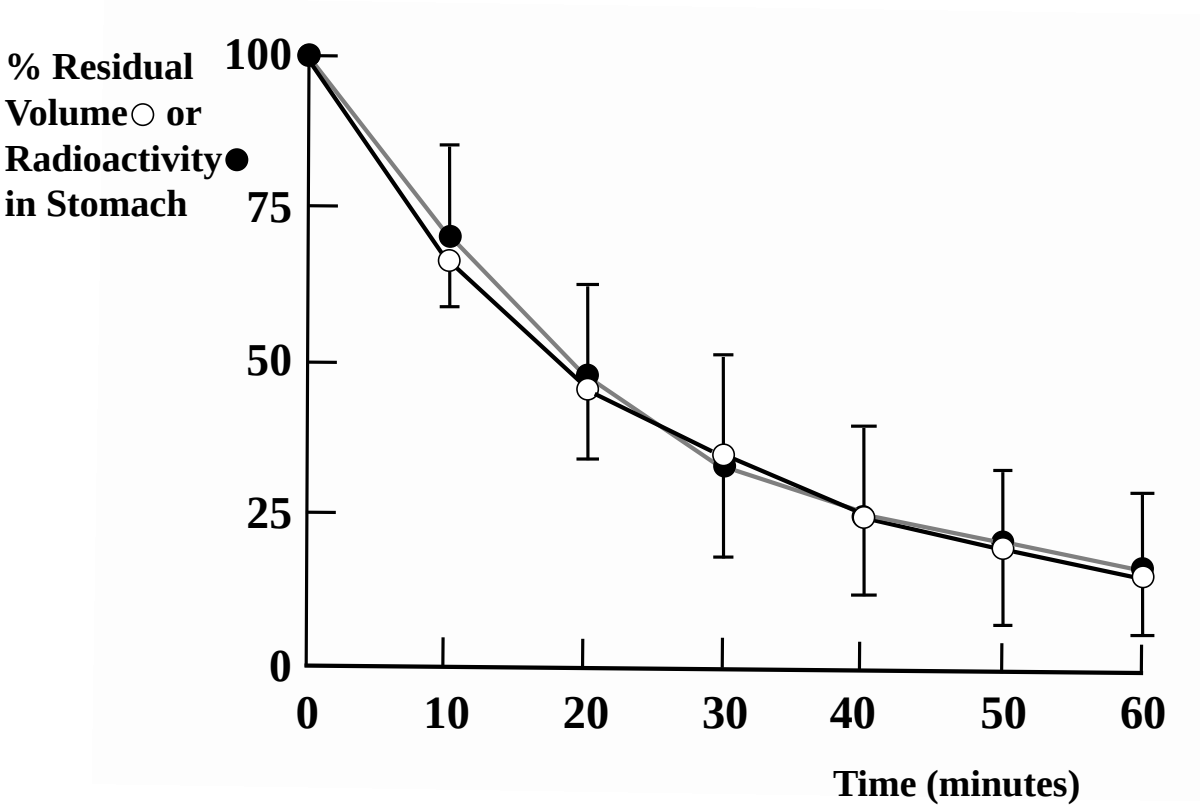
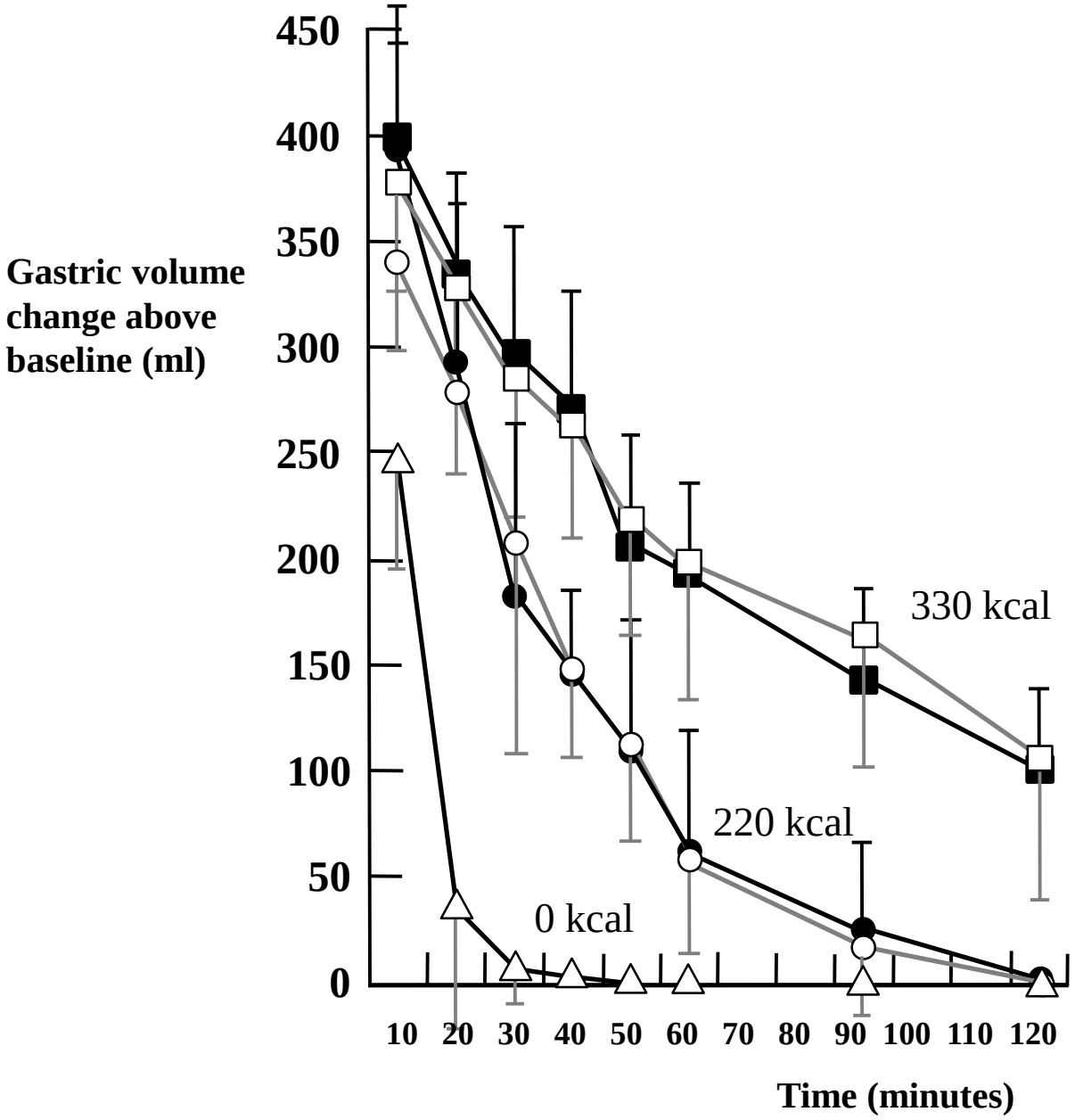

% Residual
Volume○ or
Radioactivity●
in Stomach
100
75
50
25
0
0
10
20
30
40
50
60
Time (minutes)

Figure 3


Gastric volume change above baseline (ml)
450
400
350
300
250
200
150
100
50
0
330 kcal
220 kcal
0 kcal
10 20 30 40 50 60 70 80 90 100 110 120
Time (minutes)

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MCQ Question 1

Question

Regarding studies of stomach emptying in healthy adult volunteers following a meal containing solid food, which of the following statements can be regarded as true:

a) Emptying of the solid component can be regarded as exponential over time.

b) The half-time of emptying of the solid component depends upon the size of the meal.

c) A large meal will have largely left the stomach after 6 hours.

d) It is helpful to think of emptying of the solid component as occurring at a rate of 1-1.5 g/min.

e) The liquid component of a meal containing solids empties at about the same rate as the solid component.

Answers

a) False. The solid component tends to empty at a rate that is more closely linear with respect to time. It is the liquid component that tends to empty in a manner that is more exponential with respect to time.

b) True. Because the solid component leaves the stomach at a fairly constant rate measured in g/min (see (d) below), the time to half emptying depends very markedly on the size of the meal.

c) False. The data of Moore et al (1981) rather alarmingly suggest that 30% of the solid component (and about 25%) of the liquid component of a large meal remain in the stomach after 6 hours.

d) True. This was mentioned under (b) above. It is the finding from several studies and suggests that the stomach can regulate its emptying to match the process of digestion and assimilation by the intestine.

e) False. The liquid component is found to empty faster and with a more exponential pattern than the solid component, which empties in a more linear pattern with respect to time.

MCQ Question 2

Question

Regarding studies of stomach emptying in healthy adult volunteers following the intake of only liquids, which of the following statements can be regarded as true:

a) Emptying can be regarded as exponential over time

b) The half-time of emptying of the solid component depends upon the calorific value of the drink.

c) Any drink can usefully be regarded as having left the stomach after 2 hours.

d) The half-time of emptying following a drink of water is commonly less than 30 minutes.

e) Addition of 20% milk to tea markedly increases the half-time of emptying.

Answers

a) True. Studies involving liquid meals/drinks tend to show an exponential emptying of the stomach.

b) True. Recent research by Okabe et al (2015) in the BJA has suggested that the half-time of emptying depends upon calorific content of drinks, and can vary quite markedly from 10-15 min for 500 ml of water to 40-50 min for 500 ml of milk.

c) False. About 20% of a calorific drink such as milk may remain in the stomach 2 hours after drinking.

d) True. A number of studies have identified short half-times of emptying after water (see (b) above).

e) False. Recent studies have been unable to find an effect of a modest amount of milk on the time of emptying, even though a small effect might be anticipated from the findings about calorific content of drinks mentioned above.

MCQ Question 3

Question

Regarding the classic publication by Mendelson in 1946 the following comments are appropriate:

a) The term ‘Mendelson’s Syndrome’ has become attached to death from airway obstruction by solid food in the trachea.

b) Mendelson’s study related to aspiration of stomach contents during obstetric anaesthesia.

c) Mendelson found that there was a high mortality rate in those patients who became cyanosed and dyspnoeic following aspiration of liquid into the lungs.

d) At the time of Mendelson’s study endotracheal tubes markedly reduced the incidence of aspiration.

e) Mendelson supplemented his study in patients with measurements made on primates.

Answers

a) False. Although his paper reported deaths from airway obstruction, the term ‘Mendelson’s Syndrome’ has become applied to the much more frequently reported syndrome of cyanosis, tachycardia & dyspnoea associated with aspiration into the lungs of liquid of low pH.

b) True. His study was exclusively in obstetric patients.

c) False. The only deaths reported in his study were attributable to airway obstruction from solid food.

d) False. At that time endotracheal tubes had no cuffs and had little influence on the occurrence of aspiration.

e) False. It was studies on the effect of acid instillation into the lungs of adult rabbits that were reported.

MCQ Question 4

Question

Regarding published guidelines on starvation in adult patients undergoing elective surgery, the following statements are appropriate:

a) The American Society of Anaesthesiologists (ASA) (2011) recommends an overnight fast from a meal containing solid food as the gold standard.

b) The Scandinavian guidelines from 2005 included the recommendation of a drink of 150 ml of water with oral medication up to 1 hour before anaesthesia.

c) The European Society of Anaesthesiology (2011) recommends an 8-hour fast from solid food following a large meal.

d) The European Society of Anaesthesiology (ESA) (2011) permits the intake of tea or coffee with ~20% milk added up to 2 hours before surgery.

e) Both the ASA and ESA guidelines recommend regular use of pre-operative medication to reduce stomach acid secretion in adult patients undergoing elective surgery.

Answers

a) False. The ASA guidelines make no mention of a ‘gold standard’ and indeed are discouraging an overnight fast as something that is outdated. The recommended duration of starvation is as follows: 6 h from a ‘light meal or non-human milk’ and 8 h or more from a meal containing ‘fried or fatty foods or meat’.

b) True. This recommendation is published in Soreide et al (2005). Recent experiments have tended to reinforce this recommendation as entirely appropriate.

c) False. The ESA guideline recommends a 6-hour fast as follows: “solid food should be prohibited for 6 h before elective surgery in adults”.

d) True. Interestingly, the publication made the point that one member of the committee drawing up the guidelines did not feel able to agree with this recommendation. Experiments published since 2011 have tended to reinforce the appropriateness of the majority recommendation of the panel.

e) False. Both sets of guidelines recommend that these drugs are NOT used regularly in the adult non-obstetric population.