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Lifestyle measures in the management of gastro-oesophageal reflux disease: clinical and pathophysiological considerations

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***Abstract*:** Several lifestyle and dietary factors are commonly cited as risk factors for gastro-oesophageal reflux disease (GORD) and modification of these factors has been advocated as first-line measures for the management of GORD. We performed a systematic review of the literature from 2005 to the present relating to the effect of these factors and their modification on GORD symptoms, physiological parameters of reflux as well as endoscopic appearances. Conflicting results existed for the association between smoking, alcohol and various dietary factors in the development of GORD. These equivocal findings are partly due to methodology problems. There is recent good evidence that weight reduction and smoking cessation are beneficial in reducing GORD symptoms. Clinical and physiological studies also suggest that some physical measures as well as modification of meal size and timing can also be beneficial. However, there is limited evidence for the role of avoiding alcohol and certain dietary ingredients including carbonated drinks, caffeine, fat, spicy foods, chocolate and mint.

Keywords: alcohol, gastro-oesophageal reflux disease, head of bed elevation, lifestyle modification, obesity, posture, smoking, weight loss

Introduction

Gastro-oesophageal reflux disease (GORD) is characterized by symptoms and/or mucosal damage produced by the abnormal reflux of gastric contents into the oesophagus [DeVault and Castell, 2005]. Typical symptoms include heartburn and acid regurgitation. GORD is an important problem worldwide. Frequent or severe GORD symptoms are associated with work loss [Henke *et al.* 2000] and impaired health-related quality of life [Revicki *et al.* 1998]. It is a risk factor for adenocarcinoma of the oesophagus, an increasingly prevalent malignancy in Western populations [Lagergren, 2006]. In the Western world, GORD, defined here as at least weekly heartburn and/or acid regurgitation, has a higher prevalence of 10–20% compared with less than 5% in Asia [Dent *et al.* 2005]. However, recent increases in prevalence have been reported in Asian populations [Fujimoto, 2004; Lim *et al.* 2005; Ho *et al.* 2006], suggesting that lifestyle factors may contribute to GORD development.

GORD is traditionally managed in a stepwise fashion, beginning with modification of lifestyle factors and use of over-the-counter medications such as antacids [DeVault and Castell, 2005], stepping up to potent pharmacological agents and antireflux surgery. However, the introduction of potent acid suppressants has rendered lifestyle measures unfashionable. An expert committee did not even consider them to be sufficiently effective to justify a trial as initial or long-term therapy [Dent *et al.* 1999], citing a 'remarkable lack of data in this area' and suggesting that 'many patients seeking medical advice have already tried lifestyle measures and antacids and found them ineffective' [Dent *et al.* 1999]. However, 65% of 130 consecutive patients with GORD presenting to an English district general hospital had no knowledge of lifestyle interventions and only 28% had been informed of such measures by their general practitioners [Kang, 2000]. To date there is no trial evidence that directly compares drug therapy with lifestyle interventions.

In 2006, Kaltenbach and colleagues reviewed the evidence base relating to lifestyle measures against gastro-oesophageal reflux and concluded that, while weight loss and head of bed elevation were

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effective interventions for GORD, evidence was lacking to support tobacco or alcohol cessation or other dietary measures [Kaltenbach *et al.* 2006]. We have performed a systematic review of the literature from 2005 to the present relating to lifestyle measures against GORD. We separately considered the effect of these factors and their modification on symptoms, physiological parameters of reflux as well as endoscopic appearances, since these different indices may be discordant for individual patients. The role of such measures in GORD management in the era of potent acid suppressant therapy is discussed.

Methods

A Medline search was conducted from 2005 to 20 March 2014, limited to original articles in the English language, using the following keywords: gastro-oesophageal reflux disease, gastroesophageal reflux disease, oesophagitis, esophagitis, heartburn, reflux, lifestyle modification, smoking, alcohol, obesity, weight loss, caffeine, coffee, citrus, chocolate, mint, carbonated beverages, spicy foods, fatty foods, head of bed elevation, late-evening meal, nocturnal symptoms, regurgitation, posture, postural, sleep, body position, left lateral decubitus, fat, low fat, curry, antacid, proton-pump inhibitors, omeprazole, lansoprazole, rabeprazole, esomeprazole, cimetidine, H2 antagonist, ranitidine and Gaviscon®.

Manual searches were made using the reference lists from review and original articles to retrieve other papers relevant to the topic. The two authors independently reviewed the results of the literature search and discussed the inclusion of articles where there were discrepancies.

Results

The initial Medline search yielded 1537 abstracts, of which 218 were included in the final analysis.

In general, the strongest evidence is obtained from systematic reviews or meta-analyses. The next best source of evidence is interventional studies such as randomized controlled trials, which are in turn superior to observational studies such as cohort studies, case-control studies and cross-sectional studies.

Several cross-sectional epidemiological studies assessed risk factors for GORD symptoms and endoscopic changes. Other studies, generally on small numbers of subjects, assessed the effects of specific short-term dietary or physical interventions on reflux symptoms and physiological parameters. There were very few, if any, cessation studies apart from extremely short-term ones.

Recently published reports from the Nord-Trøndelag Health (HUNT) study provided the most definitive evidence to date on the effect of weight reduction and smoking cessation on GORD symptoms. Data were collected on a wide range of health-related topics by means of several population based surveys: HUNT1 (1984–1986); HUNT2 (1995–1997); HUNT3 (2006–2008); and a short questionnaire (Mini-Q) sent to non-participants after HUNT 3 in 2009. In HUNT 2 and HUNT 3/Mini-Q, the GORD symptom status of participants was determined for the previous 12 months. Covariables such as sex, age, alcohol consumption, education, physical exercise, body mass index (BMI) and use of antireflux medication were then evaluated in terms of their association with GORD symptoms.

Body weight

The increasing prevalence of GORD is believed to be linked to the global rise in obesity [Dent *et al.* 2005; Locke, *et al.* 1999; Pandolfino *et al.* 2008]. Epidemiological studies show that weight gain and/or obesity is a risk factor for GORD [Locke *et al.* 1999; Murray *et al.* 2003; Nilsson *et al.* 2003; Delgado-Aros *et al.* 2004; Kulig *et al.* 2004; Nandurkar *et al.* 2004; El Serag *et al.* 2005a; Hampel *et al.* 2005; Jacobson *et al.* 2006; Corley *et al.* 2007; Murao *et al.* 2011; Eslick, 2012; Pandeya *et al.* 2012]. There is a dose-response relationship between BMI or obesity (defined as BMI $>$ 30), GORD symptoms [Jacobson *et al.* 2006] and complications such as erosive oesophagitis [El Serag *et al.* 2005a; Hampel *et al.* 2005], Barrett's oesophagus [El Serag *et al.* 2005b] and oesophageal adenocarcinoma [Hampel *et al.* 2005]. A UK population-based cross-sectional study of 10,537 subjects found BMI to be strongly and positively related to the frequency of heartburn and acid regurgitation symptoms in a dose-response fashion. The odds ratio (OR) for heartburn and acid regurgitation symptoms occurring at least weekly in overweight subjects, compared with those of normal BMI, were 1.82 [95% confidence interval (CI): 1.33–2.50] and 1.50 (95% CI: 1.13–1.99), respectively. In obese participants, the corresponding ORs were 2.91 (95% CI: 2.07–4.08)

and 2.23 (95% CI: 1.44–3.45), respectively [Murray *et al.* 2003]. Another study found the risk of hospitalization for GORD to increase by 1.22 for each increment in BMI of 5 [hazard ratio (HR) = 1.22 per 5 kg/m^2, 95% CI = 1.13–1.32) [Ruhl and Everhart, 1999b]. Obesity is also associated with increased numbers of reflux events and oesophageal acid exposure in pH and manometric studies [Fisher *et al.* 1999; Wu *et al.* 2007; Ayazi *et al.* 2009; Fornari *et al.* 2009] and increased risk of erosive oesophagitis [Nilsson *et al.* 2002; El Serag *et al.* 2007; Kang *et al.* 2007; Chung *et al.* 2008; Nam *et al.* 2010].

The pathophysiological mechanisms underlying the association between obesity and reflux are not fully understood. Although increasing BMI was associated with oesophageal acid exposure in a retrospective study of patients referred for oesophageal pH monitoring, BMI itself was not an independent predictive factor. In contrast, specific parameters including reduced lower oesophageal sphincter (LOS) pressure, increased intragastric pressure and the presence of hiatal hernia were thought to be more important contributing factors [Burgerhart *et al.* 2014]. The extent to which mechanical effects explain the association between obesity and GORD is uncertain. Other factors may also be relevant in GORD pathophysiology including: enhanced sensitivity to the presence of acid in the oesophagus [Mercer *et al.* 1987]; increased output of bile and pancreatic enzymes caused by vagal abnormalities associated with obesity [Wisen *et al.* 1988], leading to increased refluxate toxicity to oesophageal mucosa; and the release of metabolic and humoral mediators from visceral adipose tissue [Chung *et al.* 2008; Nam *et al.* 2010; Tilg and Moschen, 2010].

Advice about weight reduction is a standard part of GORD management. A recent report of 30,000 individuals with symptomatic GORD in the HUNT study showed a dose-dependent relationship between weight reduction and improvement in reflux symptoms, as well as increased treatment success with pharmacologic therapy [Ness-Jensen *et al.* 2013]. In this study, the large general population sample was surveyed twice approximately 10 years apart for health-related items such as reflux symptoms, use and type of GORD medication, and anthropomorphic measures such as body weight, height and BMI. For individuals with a >3.5 units decrease in BMI, adjusted ORs for loss of GORD symptoms ranged from 1.98 to 3.95 based on the frequency of antireflux medication previously required. The corresponding ORs for loss of severe GOR symptoms were 0.90 and 3.11, respectively [Ness-Jensen *et al.* 2013].

The strengths of this study include its prospective design, large sample size and assessment period of around 10 years. In addition, the wide selection of variables assessed allowed correction for potential confounding factors. Weaknesses included the potential for selection bias due to loss of participants to follow up and recall bias due to a recall period of only 12 months. Short-term fluctuations in symptoms could not be assessed because patients were only surveyed twice in the 10 year study period. The authors' definition of GORD symptoms was based only on participants' reporting one of only three responses: 'no complaints', 'minor complaints' or 'severe complaints'. Importantly the study only assessed symptoms and not endoscopic appearances or physiological parameters [Ness-Jensen *et al.* 2013].

Two uncontrolled prospective cohort studies in which patients were encouraged to lose weight showed a negative correlation between weight loss and reflux symptoms [Fraser-Moodie *et al.* 1999; Singh *et al.* 2013]. A US population-based study followed 637 individuals over a median of 10.5 years and found no relation between weight change and change in GORD symptoms, but self-reported height and weight were used in this study [Cremonini *et al.* 2006].

Evidence regarding the effect of weight loss on GORD physiological parameters is conflicting. When 20 obese patients with GORD were randomized to either a low calorie or an unrestricted diet for 6 months, there was no correlation between weight reduction and GORD symptoms or pH measurements [Kjellin *et al.* 1996]. A study of 32 obese patients by Mathus-Vliegen and colleagues showed that weight loss of 9.7% over 13 weeks significantly decreased upright oesophageal pH < 4 (8.0 *versus* 5.5%) as well as postprandial reflux episodes (49 *versus* 32) [Mathus-Vliegen *et al.* 2003].

Reports on the effect of bariatric surgery on GORD have not been clear cut [Morino *et al.* 1997; Ovrebo *et al.* 1998; Westling *et al.* 1998; Dixon and O'Brien, 1999; Frigg *et al.* 2004; Perry *et al.* 2004]. This partly reflects the different operations involved. Indeed, gastric banding may be expected to exacerbate reflux symptoms.

Waist circumference may be relevant in the pathophysiology of GORD, independent of BMI. In a large cross-sectional study of 80,000 subjects, waist circumference was associated with increased risk of reflux symptoms, independent of BMI [Corley *et al.* 2007]. A study of 582 patients referred for physiological investigation of typical GORD symptoms found an association between increased waist circumference and oesophageal dysfunction (reduced LOS pressure and abdominal LOS length), increased acid exposure and reflux symptoms [Anggiansah *et al.* 2013].

Smoking

Epidemiological studies, mostly population-based, suggest that smoking is a risk factor for GORD. Questionnaire studies reported a significant association between smoking and reflux symptoms [Chattopadhyay *et al.* 1977; Tibbling *et al.* 1995; Watanabe *et al.* 2003; Fujiwara *et al.* 2011]. Multivariate analysis from a case-control study of 3153 patients with severe heartburn or regurgitation revealed that the risk of reflux symptoms was significantly increased by 70% among daily smokers with a greater than 20-year tobacco use history compared with nonsmokers (OR 1.7, 95% CI 1.5–1.9) [Nilsson *et al.* 2004]. A recent monozygotic co-twin control study that adjusted for the potential effects of genetic predisposition and nongenetic familial effects found that smoking was a risk factor for frequent reflux symptoms [Zheng *et al.* 2007]. In contrast, an Australian study of 1580 subjects by Pandeya and colleagues showed no significant associations between GORD symptoms and smoking [Pandeya *et al.* 2012].

A number of mechanisms may account for the association between smoking and reflux. Smoking prolongs oesophageal acid clearance [Kahrilas and Gupta, 1989] and reduces LOS pressure [Stanciu and Bennett, 1972; Dua *et al.* 1998], although this normalizes within minutes after finishing a cigarette [Stanciu and Bennett, 1972]. Abrupt increases in intra-abdominal pressure during coughing or deep inspiration are also associated with reflux symptoms in smokers [Kahrilas and Gupta, 1990]. Physiological studies assessing oesophageal pH or acid exposure report inconsistent results: smokers did not exhibit increased acid exposure time [Berenson *et al.* 1987; Pehl *et al.* 1997b; Smit *et al.* 2001] but experienced more 'reflux episodes' [Schindlbeck *et al.* 1987].

Several studies addressed the effect of smoking and its cessation on physiological parameters. Schindlbeck and colleagues compared 30 healthy volunteers, half of whom were smokers, with 10 smokers with GORD and found that, although smokers had more reflux episodes than nonsmokers, 24-hour smoking cessation did not reduce the total oesophageal acid exposure [Schindlbeck *et al.* 1987]. In another study, 8 male GORD patients underwent 24-hour oesophageal pH monitoring while smoking at least 20 cigarettes. The protocol was repeated the following day with patients abstaining. Cessation of smoking decreased the number of daily reflux episodes, but did not significantly affect total oesophageal acid exposure [Waring *et al.* 1989]. Although neither investigation demonstrated improved GORD symptoms, both were limited by very small sample sizes and only studied the immediate effects of smoking cessation. Kadakia and colleagues found that smoking after a 48-hour period of abstinence significantly increased acid exposure time [Kadakia *et al.* 1995].

The HUNT study, referred to earlier, showed that smoking cessation markedly improved reflux symptoms. Stopping or reducing smoking resulted in an almost two-fold improvement in severe symptoms (OR 1.78, 95% CI 1.07–2.97) in individuals with normal BMI taking weekly antacids medication, compared with those who continued to smoke [Ness-Jensen *et al.* 2014].

Alcohol

There are several possible reasons why alcohol may exacerbate GORD. It may increase acid secretion through gastrin stimulation, reduce LOS pressure, increase spontaneous LOS relaxations, or impair oesophageal motility and gastric emptying [Bujanda, 2000].

Alcohol intake has been documented to cause reflux symptoms and decrease oesophageal pH in healthy subjects without GORD [Kaufman and Kaye, 1978; Vitale *et al.* 1987; Rubinstein *et al.* 1993]. For example, Kaufman and Kaye gave 12 healthy individuals modest quantities of 100 proof vodka or water before 3 hours of continuous distal oesophageal pH monitoring. After alcohol, 11/12 subjects had increased numbers of reflux episodes and mean reflux scores [Kaufman and Kaye, 1978]. However, another challenge study reported normal 24-hour pH measurements following red wine consumption [Grande *et al.* 1997].

In contrast, Australian [Pandeya *et al.* 2012], American [Talley *et al.* 1994] and multinational [Stanghellini, 1999] cross-sectional studies showed no association between alcohol consumption and GORD symptoms. Similarly Nilsson and colleagues examined data from two consecutive Norwegian public health surveys and did not find alcohol to be a risk factor for reflux symptoms [Nilsson *et al.* 2004]. Interestingly Shapiro and colleagues, who reported similar results, documented that alcohol was associated with reduced perception of reflux events [Shapiro *et al.* 2007]. A recent observational study by Reding and colleagues showed binge drinking, defined as $\geqslant$4 alcohol-containing drinks per day not to be associated with heartburn in women with irritable bowel syndrome (IBS). Since there was a positive association with other gastrointestinal (GI) symptoms, the lack of association with heartburn is unlikely to be caused by underreporting of symptoms. Moderate prior day alcohol consumption (2–3 drinks) was associated with a reduced risk of heartburn in the non-IBS control group (OR 0.2, 95% CI 0.1–0.8), although there was no dose-dependent response [Reding *et al.* 2013].

Other randomized and cross-sectional studies suggest that alcohol is an independent risk factor for symptomatic GORD [O'Leary *et al.* 2003; Rosaida and Goh, 2004; Wang *et al.* 2004]. In a cross-sectional study of 87 oesophagitis patients, alcohol consumption was 294.2 ± 73.4 g/week in the 23 symptomatic individuals compared with (53.2 ± 13.4) g/week in the 64 asymptomatic participants [Nozu and Komiyama, 2008]. A Chinese study of over 2500 subjects demonstrated an association between chronic excessive alcohol abuse and GORD: reflux symptoms occurred in 43% of heavy ($\geqslant$210 g/week) alcohol users compared with 16% of nondrinkers (OR 2.85, 95% CI 1.67–4.49; $p < 0.01$) [Wang *et al.* 2004].

Diet

Many patients and physicians associate reflux symptoms with specific dietary factors [Oliveria *et al.* 1999; Bolin *et al.* 2000]. Clinical and experimental studies also show that certain foods and drinks may induce or worsen parameters such as LOS pressure and oesophageal acid exposure [Becker *et al.* 1989; Hills and Aaronson, 1991; Murphy and Castell, 1988]. Accordingly patients are often advised to avoid these foods. However, the exact effects of dietary components on GORD symptoms and reflux parameters are difficult to work out.

Carbonated drinks. In a questionnaire study of almost 400 GORD patients, citrus juice, carbonated soft drinks, alcohol, coffee and tea were cited as heartburn precipitants [Feldman and Barnett, 1995]. While these beverages are acidic, they may contribute to heartburn in other ways. Bernstein test-positive patients were still highly sensitive to intraoesophageal infusions of orange juice even after the pH was adjusted to 7, suggesting that they are not just sensitive to a low pH [Price *et al.* 1978]. Citrus drinks did not reduce LOS pressure in patients with heartburn and actually increased pressure in asymptomatic controls [Cranley *et al.* 1986].

Carbonated soft drink consumption was predictive of nocturnal heartburn in a multivariate analysis of 15,314 US subjects (OR 1.31, 95% CI 1.16–1.48) [Fass *et al.* 2005]. A study of healthy individuals by Crookes and colleagues, available only in abstract form, found no difference in LOS pressure with ingestion of carbonated water, caffeinated cola, or caffeine-free cola compared with water ingestion. Based on these findings, the authors suggested gas, rather than caffeine content or pH, as the causative factor.

Caffeine. Large epidemiological studies found no association between coffee consumption and GORD [Stanghellini, 1999; Wang *et al.* 2004; Pandeya *et al.* 2012]. A large Norwegian case-control study even demonstrated a negative association between coffee and risk of reflux symptoms [Nilsson *et al.* 2004]. Both caffeinated and decaffeinated coffee increase LOS pressure [Cohen and Booth, 1975; Cohen, 1980]. In contrast, another study revealed increased LOS pressure in both normal volunteers and reflux oesophagitis after coffee consumption [Thomas *et al.* 1980]. Pehl and colleagues found that decaffeinated coffee was associated with reduced acid exposure time compared with caffeinated coffee [Pehl *et al.* 1997a].

The heterogeneity of the available literature may be explained by different varieties of coffee and different processing methods. The effect of coffee on GORD may also vary depending on whether coffee is consumed with food or on an empty stomach. When 10 healthy volunteers were given coffee in the fasting state, no significant changes in LOS pressure were observed compared with a decrease when coffee was taken after a test meal. Consumption of the test meal alone also reduced LOS pressure, suggesting that GORD symptoms

after coffee may reflect the effect of a previous meal on LOS pressure [Salmon *et al.* 1981].

Dietary fat. Although patients with GORD are often advised to reduce dietary fat intake, data regarding the effect of fat ingestion on GORD symptoms and physiological parameters are limited and inconsistent. Fox and colleagues reported that reflux symptom frequency increased in 15 patients with reflux symptoms after a high fat meal, this effect being unaffected by calorie density. A prospective study of 89 women during the third trimester of pregnancy showed that consumption of polyunsaturated or monounsaturated fatty acids was higher in those with heartburn than those without [Dall'Alba *et al.* 2010].

In an epidemiological study of 12,349 individuals over a median of 18.5 years, Ruhl and Everhart found no association between fat intake and reflux disease hospitalization [Ruhl and Everhart, 1999a]. However, hospitalization is rarely required for GORD.

Shapiro and colleagues showed that fat consumption induced reflux events in 50 subjects with heartburn [Shapiro *et al.* 2007]. Nebel and Castell found that fatty meals decreased LOS pressure in 10 healthy male volunteers compared with protein meals of equivalent caloric value, which increased LOS pressure [Nebel and Castell, 1973]. Iwakari and colleagues demonstrated that a high fat meal significantly increased oesophageal acid exposure time in the 3 hour postprandial period compared with a low fat meal in 20 healthy individuals [Iwakiri *et al.* 1996b]. Notably, the difference was not significant in the first or third hours postprandially and only reached significance in the second hour [Iwakiri *et al.* 1996a]. In contrast, Becker and colleagues found that the fat content of a meal was not significantly associated with oesophageal pH abnormalities in either GORD patients or healthy volunteers [Becker *et al.* 1989]. Penagini and colleagues compared a high fat (52% fat) with a balanced (24% fat) meal in both 13 normal subjects and 14 GORD patients, and found that the fat content of the meal did not affect the rate of reflux, oesophageal acid exposure, transient LOS relaxation rate or basal LOS pressure [Penagini *et al.* 1998]. A similar study by Pehl and colleagues in 12 healthy individuals also found no differences in reflux parameters after high or low fat meals [Pehl *et al.* 1999]. Fox and colleagues reported that oesophageal acid exposure increased after a high calorie meal, but was unaffected by the fat content of the meal [Fox *et al.* 2007]. The authors concluded that calorie content rather than fat content determines the extent of oesophageal acid exposure. Fat content, in contrast, does not worsen oesophageal acid exposure, but may heighten patient sensitivity.

Spicy food. Spicy foods were cited by 88% of patients with GORD symptoms as a heartburn precipitant [Nebel *et al.* 1976]. Despite this, limited data exist for the effects of spicy food on GORD physiological variables. Onions increased the number of reflux episodes and oesophageal acid exposure time in GORD patients compared with controls in a small study of 32 individuals [Allen *et al.* 1990]. Ingestion of curry induced reflux symptoms in both GORD patients and healthy volunteers. Additionally, it also exacerbated pathological reflux in patients with GORD [Lim *et al.* 2011]. In contrast, a cross-sectional study by Pandeya and colleagues showed no association between spicy food consumption and GORD symptoms [Pandeya *et al.* 2012].

Meals

Late meals. American College of Gastroenterology guidelines recommend that patients refrain from eating within 3 hours of sleeping [DeVault and Castell, 2005]. Although pathophysiological principles suggest that late evening meals should exacerbate GORD, this has not been well studied.

Two studies showed different effects of evening meal timing on 24-hour intragastric acidity. Duroux and colleagues observed lower intragastric pH between midnight and 7 a.m. after late meals (9 p.m.) compared with earlier meals (6 p.m.) [Duroux *et al.* 1989]. In contrast, Lanzon-Miller and colleagues found that intragastric acidity was unaffected by the timing of the evening meal [Lanzon-Miller *et al.* 1990]. A case-control study showed a relationship between shorter dinner-to-bedtime and the risk of GORD, whether erosive or nonerosive, the OR for GORD patients who ate less than 3 hours before sleeping being 7.45 (95% CI 3.38–16.4) [Fujiwara *et al.* 2005].

In a prospective, randomized unblinded crossover trial, 32 patients with reflux symptoms consumed a standardized, refluxogenic meal with high fat content, along with a caffeinated carbonated beverage, to exaggerate any therapeutic effect, either

6 or 2 hours before going to bed for 2 consecutive nights. A significantly greater percentage supine time pH <4 was observed in the late evening meal group, especially in overweight patients ($25 \leqslant BMI \leqslant 29.9$) or those with endoscopy-diagnosed oesophagitis or hiatal hernia [Piesman *et al.* 2007]. A cohort of 337 consecutive erosive reflux disease (ERD) and nonerosive reflux disease (NERD) patients were followed up over 12 months to determine the risk factors related to GORD recurrence, defined by reflux symptoms requiring additional medication after initial recovery with 4–8 weeks of proton pump inhibitor (PPI) treatment. Sleeping within 3 hours of eating was the most significant independent factor associated with GORD recurrence. In contrast, many commonly cited GORD risk factors such as smoking, obesity or the presence of hiatal hernia were not significantly associated with recurrence [Yang *et al.* 2014].

Volume of meals. Most reflux episodes occur within the first 3 hours after eating [Dent *et al.* 1980], possibly as a result of gastric distension [Holloway *et al.* 1985]. Patients complaining of heartburn or regurgitation are therefore often advised to avoid large meals. Wu examined the effects of meal volume and frequency on reflux parameters and symptoms. A total of 15 GORD patients with heartburn were studied twice each in random order. On one day they consumed a 600 ml liquid test meal 3 times, and on the other they received six smaller 300 ml meals. On the smaller meals regimen there were fewer reflux episodes, less oesophageal acid exposure and fewer reflux symptoms [Wu, 2014].

Head of bed elevation/postural measures

Gastro-oesophageal reflux should occur more in the supine compared with an upright position due to the effect of gravity. Hence, GORD patients are traditionally advised to sleep propped up. Stanciu and Bennett studied the effect of head of bed elevation using 28 cm blocks in 63 patients with heartburn and acid regurgitation. Patients who slept with the head of bed elevated experienced significantly fewer reflux episodes, shorter reflux episodes and fewer reflux symptoms, and demonstrated faster acid clearance compared with those lying flat [Stanciu and Bennett, 1977]. In another study of nocturnal lower oesophageal acid exposure, Hamilton and colleagues reported that, although head of bed elevation using 8 inch blocks improved exposure time and clearance, the difference was not statistically significant. In contrast, sleeping on a wedge was associated with significantly less oesophageal acid exposure. Neither head of bed elevation nor the wedge affected the number of reflux episodes [Hamilton *et al.* 1988]. Harvey and colleagues compared head of bed elevation using 20 cm blocks with the use of ranitidine 150 mg twice daily in the treatment of 71 patients with endoscopically proven severe oesophagitis. Head of bed elevation was as effective in controlling symptoms as ranitidine; over a 6-week period both treatments improved heartburn but not epigastric pain compared with the control group [Harvey *et al.* 1987].

Khan and colleagues evaluated the effect of head of bed elevation on GORD symptoms and lower oesophageal acid exposure using ambulatory pH monitoring. A total of 24 patients with symptomatic GORD who exhibited nocturnal reflux in a 24 hour pH study were included. In a 7 day protocol, patients slept on beds with the head end elevated by 20 cm blocks from days 2 to 7. Baseline pH was measured on day 1, with testing repeated on days 2 and 7 with the head of the bed elevated. Lower oesophageal acid exposure with the head of bed elevated was reduced from baseline in terms of mean acid exposure time, acid clearance and the number of refluxes >5 minutes. Sleep disturbances improved in 13 patients. However, symptom improvement was difficult to assess without a control group [Khan *et al.* 2012].

Left lateral versus *right lateral decubitus position*

Sleeping in the left lateral decubitus position improves nocturnal oesophageal pH time <4, oesophageal acid clearance and refluxate composition compared with lying in the right lateral position [Katz *et al.* 1994; Shay *et al.* 1996; Kapur *et al.* 1998; Khoury *et al.* 1999]. The reasons for this effect are not clear. There were no significant differences in mean resting LOS pressure [Babka *et al.* 1973] or transient LOS relaxation frequency in either position [Kapur *et al.* 1998]. The relative position of the gastro-oesophageal junction to the air–fluid interface may be important and barium studies suggest that this junction lies above the level of gastric acid in the left lateral position [Shay *et al.* 1996]. However, it would be a challenge for patients to implement this lifestyle modification.

Datta and colleagues performed 24-hour ambulatory pH monitoring in 15 male patients with

NERD and pathological upright but not supine reflux. They made 30-minute recordings 3 hours or more after the last meal with patients adopting various postures in a randomized order: supine; supine with 30 degrees head end elevated; upright; and right and left lateral recumbent positions. Oesophageal acid exposure and reflux episode duration was significantly lower in supine ($p < 0.05$) and supine with 30 degrees head end elevated ($p < 0.005$) compared with the other positions [Datta *et al.* 2011]. These results are unexpected because the supine position is conventionally thought to exacerbate reflux, whereas the left lateral decubitus position had been reported to help reduce symptoms. These studies were performed on patients with upright reflux and NERD, in whom the predominant underlying pathophysiology is thought to be transient lower oesophageal relaxations. The results are therefore probably not applicable to patients with nocturnal or bipositional symptoms in whom the predominant pathophysiology is thought to be reduced LOS pressure and hiatus hernia [Dent, 1998].

Physical activity

Everyday clinical experience indicates that vigorous exercise exacerbates reflux symptoms. Consistent with this, pH monitoring studies have shown that strenuous exertion such as running provokes GORD [Clark *et al.* 1989; Kraus *et al.* 1990]. For example, Clark and colleagues reported that 1 hour of strenuous exercise induced physiological reflux in 12 normal subjects, worsened by eating prior to exercise [Clark *et al.* 1989]. However, large Japanese, Norwegian and German population health surveys revealed higher prevalence rates of GORD symptoms in physically inactive subjects [Nilsson *et al.* 2004; Nocon *et al.* 2006; Murao *et al.* 2011]. Exercise for 30 minutes or more at least once per week reduced the risk of reflux symptoms, with once weekly sessions associated with a 50% decreased risk compared with individuals who never did any physical exercise of at least 30 minutes duration each week (OR 0.5, 95% CI 0.4–0.7) [Nilsson *et al.* 2004]. It is possible that this apparent association may be may be confounded by other related risk factors such as high BMI. A more recent multicentre Pakistani cross-sectional study of 1875 individuals showed that regular post dinner walking was associated with less GORD symptoms compared with lying posture after eating (walking: OR 0.66, 95% CI 0.5–0.88) [Karim *et al.* 2011]. However, post dinner sitting was also associated with reduced symptoms compared with lying, albeit with lower risk reduction than walking. The investigators did not compare the risks of reflux in subjects who reported post dinner sitting and walking [Karim *et al.* 2011].

Discussion

Since acid suppression is effective and safe, lifestyle measures are currently not fashionable and not emphasized by most doctors. GORD is a chronic condition which often requires long-term medication. The cost and potential side effects of long-term pharmacologic therapy increases the importance of considering lifestyle interventions since these measures may reduce the need for acid suppression.

Conflicting results exist for the association between smoking, alcohol and various dietary factors in the development of GORD. These inconsistencies are due in part to differences in methodology. For example, while much data are available regarding the effect of smoking and tobacco use on symptoms of GORD, reports on the effect of fatty foods on GORD are mostly acute physiological rather than epidemiological studies. This could be because fat intake is difficult to study in everyday life. Inconsistent findings relating to alcohol and GORD may be explained by the different effects of various alcoholic beverages such as beer, wine or spirits. Equivocal findings may also be due to different definitions. For example, GORD has been defined by symptoms, pathophysiologic parameters or endoscopic findings. The frequency of symptoms used to define GORD varies from twice weekly [Watanabe *et al.* 2003] to once per year [Nilsson *et al.* 2004]. A standardized system of assessment of reflux symptoms would help meaningful comparisons between studies.

Even if a lifestyle variable is associated with GORD, modification of that variable may not necessarily resolve the situation. For example, the effect of weight loss on GORD is conflicting, which is perhaps not unexpected since high BMI itself is associated with other GORD risk factors such as hiatal hernia, which do not improve after weight loss. In this way, being overweight can increase the risk of reflux but weight loss may have only a limited therapeutic effect. Acute lifestyle changes used in many protocols may not produce the same effects as long-term modification required for GORD management.

Studies on the effect of lifestyle modifications on physiological reflux parameters generally involve small number of subjects and are hence prone to type 2 statistical errors. While a number of dietary components are reported to precipitate reflux symptoms and patients are often advised to abstain from these items, few cessation studies have been performed. Even if particular dietary items cause symptomatic GORD and physiological changes, such findings may not necessarily be confirmed by food questionnaire studies which can falsely report nonassociations if patients actively avoid these food items.

Notwithstanding these limitations, this review allows us to draw several conclusions regarding the use of lifestyle measures in the management of GORD. Much data confirm an association between smoking and high BMI on GORD and the beneficial effects of weight reduction and smoking cessation on GORD symptoms. Eating habits and head of bed elevation have also been shown to be beneficial, although studies included small numbers of patients. In contrast, while there are data linking use of alcohol and particular dietary ingredients on GORD symptoms and pathophysiology, cessation studies are seldom carried out and there is limited evidence for a beneficial effect of avoidance of these dietary ingredients.

Lifestyle measures may negatively impact on the quality of life. For example, patients may enjoy drinking alcohol, eating late meals and consuming fatty foods. This potential negative effect of lifestyle changes on quality of life has not been examined. However, even if particular lifestyle interventions are only slightly effective, they may have beneficial effects beyond GORD. For example, smoking cessation and weight reduction improve general health and are beneficial for many medical conditions.

In conclusion, although many lifestyle and dietary factors are commonly cited as GORD risk factors, the evidence base is limited. Much data link smoking and high BMI to GORD symptoms and physiological parameters. The large, population-based HUNT study showed that weight reduction and smoking cessation is beneficial in reducing GORD symptoms. GORD patients should therefore be strongly advised to stop smoking and those with a high BMI to lose weight. Eating habits such as small meals, early meals and elevation of the head of the bed are troublesome to implement and may adversely affect the quality of life. However, there is evidence, albeit limited, regarding their efficacy and these measures should be advocated when reflux symptoms are bothersome.

In contrast, evidence regarding the role of alcohol in the pathogenesis of GORD is conflicting and there is insufficient evidence to conclusively recommend cessation. There are variable amounts of anecdotal and experimental evidence regarding GORD symptom provocation for coffee, greasy food, spicy food, mint and chocolate. When GORD symptoms are troublesome, avoidance of these items would seem sensible as long as the decrease in quality of life through withdrawal of these items is commensurate with the extent of symptom reduction. It should be remembered that there is little or no evidence for a detrimental effect of these items on GORD itself, but only an effect on symptoms.

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