NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of catheterless oesophageal pH monitoring

A procedure of placing a wireless capsule in the gullet sending data to an external monitor that checks the level of acid which can cause symptoms of heartburn and acid regurgitation.

Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee (IPAC) in making recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in January 2006.

Procedure name

- Catheterless oesophageal pH monitoring
- Wireless oesophageal pH monitoring

Specialty society

- British Society of Gastroenterology

Description

Indications

Gastro-oesophageal reflux disease (GORD) is a common disorder whereby a backwash of gastric juices into the oesophagus leads to inflammation and pain. Symptoms may include heart burn, belching and regurgitation of gastric contents. Complications of GORD may include oesophageal stricture and Barrett's oesophagus – the latter is associated with carcinoma of the oesophagus. The frequency of exposure to gastric acid over a given period provides a measure of the severity of the disease ('acid exposure time'). Common indications for pH monitoring include symptoms refractory to proton

pump inhibitor therapy, evaluation before surgery and recurrence of symptoms following anti-reflux surgery.

Current treatment and alternatives

Ambulatory oesophageal pH monitoring is commonly undertaken by transnasal placement of a pH probe on a catheter. This may cause nasal and pharyngeal discomfort which may alter normal patient diet and activity, giving potentially erroneous results.

What the procedure involves

A catheterless pH monitoring system comprises a plastic capsule that houses a pH sensor and transmitter. The capsule continuously senses oesophageal pH and transmits the data to a pager-sized receiver worn by the patient. Every few seconds pH data is recorded. The position where the device is to be attached is determined endoscopically. Following endoscopy the device is inserted into the oesophagus and attached to the oesophageal wall by means of a system that produces a vacuum that sucks the surface of the oesophageal mucosa into a well on the side of the capsule. A spring-loaded pin is then released across the well tangential to the axis of the oesophagus to provide fixation. Correct placement and attachment of the capsule may be confirmed by endoscopy. The capsule detaches from the oesophageal wall after a few days and is excreted through the digestive tract.

Efficacy

A randomised controlled study (n = 50) found that during a 24-hour period, acid exposure time (defined as oesophageal pH < 4) in patients receiving proton pump inhibitors was 1.9% for catheterless monitoring and 4.8% for catheter-based monitoring[1]. This difference was not statistically significant. During this study the frequency of GORD symptoms was similar during monitoring with either technique; also, overall quality of life scores based on the SF-36 scale were similar between the groups. Significantly more patients undergoing the catheterless monitoring (88%) than the catheter-based monitoring (48%) were willing to have a repeat test if necessary ($p = 0.005$).

In a within-patient study, among 33 patients who had both catheterless and catheter-based monitoring, a total of 1388 reflux episodes was recorded over a 24-hour period[2]. Of these reflux episodes, 41% (563/1388) were recorded by both devices, 52% (724/1388) were recorded only by the catheter-based system and 7% (101/1388) only by the catheterless monitor. Overall the reflux episode concordance was 88% (Kappa statistic 0.76).

A non-randomised controlled study in healthy volunteers found that after calibration, the catheterless monitor identified significantly fewer reflux episodes (mean 37.9) during 24-hour monitoring than a catheter-based system (mean 69.8) ($p < 0.05$)[3]. Whether these findings relate to asymptomatic reflux among healthy volunteers or previously undetected disease is unclear.

A case series comparing 48 healthy volunteers with 27 patients with GORD symptoms found that a cut-off of 5.3% acid exposure time over a 48-hour catheterless monitoring period had a sensitivity of 64.9% and a specificity of 94.8% for GORD[4].

Safety

Follow-up across all the studies included in the overview is based solely on the period of monitoring used; no longer term data is available.

Among patients in a case series and the catheterless monitoring arm of controlled studies the incidence of chest pain ranged from 5% (4/85)[4] to 33% (26/80)[5] to 36%***]***[1]. After the 48 hour monitoring period immediate removal of the capsule because of chest pain was requested by 2% (2/83) of patients[4].

In a randomised controlled trial the incidence of chest pain was higher with a catheterless monitor (60%) compared with a catheter-based system (24%) ($p = 0.01$)[1]. Conversely, fewer patients reported difficulty swallowing (36%) with the catheterless system than with the catheter-based approach (68%) ($p = 0.024$). In the same study significantly fewer patients with the catheterless monitoring had nose pain, runny nose, throat pain, throat discomfort and headache. Also, among patients in employment, 58% of the patients with a catheterless capsule were able to return to work during monitoring compared with 11% of those with the catheter-based system ($p = 0.049$).

In a study of 44 children age 6 to 19 years having catheterless oesophageal pH monitoring 94% (36/38) of parents were willing to allow their child to undergo further wireless pH monitoring, and all 12 patients who had previously had nasal-catheter monitoring were reported to prefer the catheterless method[7].

There were no reports in the reviewed literature of adverse events relating to the endoscopic component of the procedure.

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to catheterless oesophageal pH monitoring. Searches were conducted via the following databases, covering the period from their commencement to 12/12/05: Medline, PreMedline, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches. (See Appendix C for details of search strategy.)

The following selection criteria (Table 1) were applied to the abstracts identified by the literature search. Where these criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising methodology.
Patients	Patients with gastro-oesophageal reflux disease or asymptomatic patients
Intervention/test	Catheterless or wireless pH monitor
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on one randomised controlled study[1], one study using the same patient as their own controls[2] ('within patient study'), one non-randomised controlled study[3] and three case series[4–6]. One of the non-randomised controlled trials was of asymptomatic volunteers, and one case series included both patients with GORD and asymptomatic volunteers.

Other studies that were considered to be relevant to the procedure but were not included in the main extraction table (Table 2) have been listed in Appendix A.

Existing reviews on this procedure

There were no published reviews identified at the time of the literature search.

Related NICE guidance

Below is a list of NICE guidance related to this procedure. Appendix B details the recommendations made in each piece of guidance listed below.

Clinical guidelines

Dyspepsia: management of dyspepsia in adults in primary care. *NICE clinical guideline* no. 17 (2004). Available from: www.nice.org.uk/CG017

Table 2 Summary of key efficacy and safety findings on catheterless oesophageal pH monitoring

Abbreviations used: GI, gastrointestinal; GORD/GERD, gastro-oesophageal reflux disease; PPI, proton pump inhibitor; QOL, quality of life.

Study details	Key efficacy findings	Key safety findings	Comments
Wong W-M (2005)[1] Randomised controlled trial USA n = 50 (25 catherterless) Consecutive patients undergoing 24 hour pH monitoring. With suspected GORD Exclusion criteria included history of bleeding or coagulopathy, significant co-morbidity, severe gastric bleeding within 6 months, previous upper GI surgery, oesophageal varices, or pacemaker/cardiac defibrillator in situ. Patients received traditional pH probe (digitrapper III) or wireless pH capsule (Bravo) with first 24 hours of recording analysed. Patients kept a diet diary and were asked to report typical or atypical GORD symptoms, sleep abnormalities, adverse events. They were asked how the test interfered with daily activity. Mean age: 51 years, male 52%, smokers 22%, alcohol consumers 28%. Mean follow-up: 1 day Disclosure of interest: study funded in part by manufacturer.	**pH measurements** (mean group values) Outcome / Standard / Bravo / p value % time pH < 4 (on PPI) / 4.8 / 1.9 / 0.70 % time pH < 4 (off PPI) / 7.8 / 10.2 / 0.78 Supine % time pH < 4 (on PPI) / 1.6 / 1.6 / 0.16 Supine % time pH < 4 (off PPI) / 6.7 / 8.0 / 0.23 Upright % time pH < 4 (on PPI) / 5.6 / 2.0 / 0.98 Upright % time pH < 4 (off PPI) / 8.7 / 12.4 / 0.52 **GORD and other symptoms** Incidence of typical and atypical GORD symptoms (heartburn and acid regurgitation) were similar across the groups; other symptoms as below. Outcome / Standard (n = 25) / Bravo (n = 25) / p value Difficulty swallowing / 68% / 36% / 0.024 Chest pain / 24% / 60% / 0.01 Absolute numbers not stated. Time spent taking meals was similar between the groups, and sleep patterns were similar. Significantly more patients in the wireless group were willing to have a repeat test − 88% vs 48% (p = 0.005) **QOL** Four of eight domains of the SF36 score were significantly better with the wireless probe; however, overall scores were not statistically different between the groups − 24.1 vs 18.0 (p = 0.191).	**Procedural complication** Minimal nose bleeding was observed during wireless capsule insertion in 84% of patients. 20% (5/25) of patients had failed nasal insertion of the wireless probe and had oral insertion. In addition, 2 patients crossed over after failed nasal insertion. **Daily activity** Outcome / Standard (n = 25) / Bravo (n = 25) / p value Nose pain / 60% / 32% / 0.047 Runny nose / 96% / 52% / 0.001 Throat pain / 48% / 16% / 0.032 Throat discomfort / 92% / 48% / 0.001 headache / 56% / 20% / 0.009 Chest discomfort / 8% / 36% / 0.037 Ability to work / 11% / 58% / 0.049 Time resting / 1.1 hours / 0 hours / 0.026 Time shopping / 0.5 hours / 1.1 hours / 0.046	Method of randomisation not stated. Blinding not possible owing to nature of the comparison. Two patients crossed over from wireless group because of discomfort during implant, but analysed as non-wireless. Power calculation provided. No significant differences between the groups in terms of demographics or clinical characteristics at baseline. One patient in the traditional test group not included in pH analaysis as they pulled out the catheter at 6 hours. Positioning of the monitor needs to be standardised, using oesophageal manometry to define the proximal margin of the lower oesophageal sphincter.

Abbreviations used: GI, gastrointestinal; GORD/GERD, gastro-oesophageal reflux disease; PPI, proton pump inhibitor; QOL, quality of life.

Study details	Key efficacy findings	Key safety findings	Comments
Des Varannes SB (2005)[2] Within-patient controlled study France n = 40 (40 catheterless) Patients with symptoms suggestive of GORD Patients excluded if they had known motility disorders or severe oesophagitis Patients received simultaneous traditional pH probe (digitrapper III) and wireless pH capsule (Bravo) with first 24 hours of recording and then an additional 24 hours of recording with wireless monitoring alone. Patients were not hospitalised and meals were not standardised. Mean age: 50 years, male 53%, Heartburn n = 7, regurgitation n = 6, both n = 26, hiatus hernia n = 14, oesophagitis (Los Angeles grade A) n = 4. Mean follow-up: 2 weeks Disclosure of interest: study supported by French national Society of Endoscopy and manufacturer.	**Operative success** The wireless catheter was deployed successfully in 90% (36/40) of patients. In one patient there was device failure. **pH measurement reliability** Recordings were available in 33 patients for the first 24 hours. There were 1388 reflux episodes, 563 (41%) of which were recoded by both devices, 724 (52%) by the traditional monitoring only and 101 (7%) by the wireless capsule only. Wireless device signal failure could only account for 10 of the 724 episodes recorded by traditional monitoring. Using calculated cut-off levels, abnormal oesophageal acid exposure was detected in 14 patients with the traditional system and 11 patients with the wireless system. Eleven patients with each system were diagnosed with reflux disease. Concordance of reflux diagnosis was 88% (Kappa = 0.76). The episodes only detected by the traditional monitoring were shorter than those detected by both devices (56 seconds vs 236 seconds) ($p < 0.0001$). Of the episodes recorded by both systems the duration recorded was not significantly different between the two; however, the minimum pH was higher with the wireless device (2.85 pH vs 2.19 pH) ($p < 0.0001$). There was a strong and significant correlation ($r = 0.87$, $p < 0.0001$) between the 24 hour acid exposure recorded by the two systems. Similar values were seen for supine and upright periods.	**Procedural complication** There was one episode each (1/40) of epistaxis and dizziness during the introduction procedure. In two cases there was poor tolerance and vomiting, and one patient failure to detach from the delivery system. The capsule had disappeared on fluoroscopic examination on day 14. **Prevalence of symptoms relating to devices** Outcome / Day 1 (both wireless and catheter) / Day 2 (wireless device alone) / p value Sleep disorder / 68% / 15% / <0.0001 Solids dysphagia / 74% / 60% / NS Liquids dysphagia / 51% / 20% / 0.006 Thoracic discomfort / 68% / 57% / NS Saliva swallowing discomfort / 51% / 29% / 0.05 From day 3 to day 14 monitored symptoms tended to decrease but dysphagia and thoracic discomfort were present for several days.	The discomfort outcomes for the first 24-hour period may be related to either device; however, discomfort outcomes have invariably improved during day 2 (wireless device). The number of reflux episodes was not different on day 1 and day 2, although diet and activity was not standardised across these days. Potential effect of learning curve in device placement and detachment, with some centres undertaking few cases. One author analysed all pH curves to determine whether reflux episodes were recorded by both or either device. Not clear whether analysis is undertaken on intention-to-treat basis or otherwise.

Abbreviations used: GI, gastrointestinal; GORD/GERD, gastro-oesophageal reflux disease; PPI, proton pump inhibitor; QOL, quality of life.

Study details	Key efficacy findings	Key safety findings	Comments
Pandolfino JE (2005)[3] Non randomised controlled study USA n = 25 (25 catheterless) Asymptomatic healthy volunters Age range 19 to 35 years, male =80% Bravo device placed orally and slimline catheter placed transnasally. Site of device confirmed by fluoroscopy. Devices corrected/calibrated by swallowing orange juice of known pH Mean follow-up: 1 day monitoring Disclosure of interest: study supported by unrestricted grant from manufacturer.	**pH measurement reliability** Data was available for 18 of 25 subjects. One person did not complete 24-hour monitoring because of discomfort, two had malfunctioning devices (on each) and four did not complete the orange juice calibration. Mean no. of reflux episodes per 24 hours: Slimline / Bravo / p value Software reported: 117.0 / 41.8 / < 0.05 Manual recalculation: 112.2 / 40.8 / < 0.05 Recalculation post calibration: 69.8 / 37.9 / < 0.05 At day 1 there was no significant difference in mean distance between the squamo-columnar junction and device slimline 7.20 ± 1.6 cm vs bravo 7.08 ± 1.38 cm ($p > 0.5$). **Calibration** A test sample of orange juice, pH 3.88, was taken before and after pH monitoring. The mean pH nadir with the slimline catheter was 3.11 (± 0.22) and for the brave capsule 3.84 (± 0.25). Recalculated post-calibration reflux episodes are presented above. **Short episodes** The number of short reflux episodes (1−3 data points with pH < 4 for slimline or 1−2 data points for bravo) was 45.5 events per 24 hours for slimline and 18.5 for bravo ($p < 0.05$). The mean acid exposure time calculated was statistically similar for both devices: slimline = 0.90%, bravo = 1.16%. For short reflux events there was 49.3% concordance between the wireless monitoring and the catheter, and for long events this was 93.5%.	None reported	Simultaneous assessment of two devices. Assessment of device location made by investigator blinded to the results of the pH study. Analysis based on second-by-second sampling required duplicating the values recorded by the slimline catheter four times and the bravo capsule six times. Reflux events were classified as simultaneously recorded if overlapping or with a lag of up to 12 seconds. Both systems will fail to detect reflux episodes that are shorter than their sampling rates. Healthy volunteers rather than those with GORD symptoms so can expect to have different reflux rates measured.

Abbreviations used: GI, gastrointestinal; GORD/GERD, gastro-oesophageal reflux disease; PPI, proton pump inhibitor; QOL, quality of life.

Study details	Key efficacy findings	Key safety findings	Comments
Pandolfino JE (2003)[4] Case series (prospective) USA n = 85 (41 GORD, 44 healthy controls) Of 41 GORD patients 63% (26/41) had oesophagitis on endoscopy 48 hour bravo wireless monitoring system placed orally to 6 cm above the sqaumo-columnar junction. Patients encouraged to maintain normal daily activity and diet. Patients' diaries of diet, supine periods and symptoms were kept. Age range =23 to 72 years, male = 46%. Follow-up: 2 days for pH monitoring Disclosure of interest: study supported by the public health service and grant from manufacturer.	**Operative success** A second wireless capsule was required in 2% (2/85) of patients as the first one failed to detach from the delivery device. 27% (23/85) of patients did not request or require sedation. 96% (82/85) of patients had viable recordings of pH for 16 hours, and 89% (76/85) had at least 36 hours of recording. One capsule prematurely detached and in seven instances there was inadequate data reception by the external monitor. **pH measurement** Median/mean time over 2 days of recording Outcome / Controls (n = 39) / GORD (n = 37) / p value % time pH < 4 / 2.0 / 6.6 / <0.05 Supine % time pH < 4 / 0.5 / 3.2 / <0.05 Upright % time pH < 4 / 2.6 / 7.6 / <0.05 Reflux events / 36.8 / 80.2 / <0.05 Reflux events > 5 minutes / 1.2 / 2.4 / <0.05 The overall acid exposure values did not differ significantly between the first and second days' monitoring. **Determining GORD from health subjects** Using a cut-off of 5.3% acid exposure time as the upper limit of normal exposure Control group (n = 44) vs all GORD patients (n = 27) 48 hours / Worst* 24 hours Sensitivity 64.9% 83.3% Specificity 94.8% 84.5% *i.e. the single day with worse acid exposure Control group (n = 44) Vs endoscopically negative reflux patients (n = 14) 48 hours / Worst* 24 hours Sensitivity 35.7% 51.7% Specificity 94.8% 84.5% *i.e. the single day with worse acid exposure	**Complications** Discomfort requiring immediate removal after 48 hours 2% (2/85) Endoscopic capsule removal required 1% (1/85) Moderate chest pain (resolved once capsule detached) 5% (4/85)	Four GORD patients were included after refusing standard catheter pH monitoring, and eight patients after previously failing to tolerate catheter. Some patients are likely to be the same as those in Pandolfino (2005), particularly data relating to comparison with catheter monitoring which is not extracted here. Major modifications were made to the monitoring hardware during the study. The use of a pH electrode attached to the oesophageal mucosa should eliminate false readings related to the movement between the sensor and the mucosa during the study period. Method for choice of cut-off value between normal reflux levels and those with GORD not stated.

Abbreviations used: GI, gastrointestinal; GORD/GERD, gastro-oesophageal reflux disease; PPI, proton pump inhibitor; QOL, quality of life.

Study details	Key efficacy findings	Key safety findings	Comments
Remes-Troche JM (2005)[5] Case series (prospective) Mexico n = 84 Consecutive patients with GORD symptoms. Patients were excluded if they had previous upper GI tract surgery, bleeding diathesis or coagulopathy, severe GI bleeding in last 6 months, oesophageal varices or significant co-morbidities. The sensor was calibrated in pH 1 and pH 7 solutions before insertion. Patients discontinued PPI, histamine receptor agonists, and antacids before the study. Bravo capsule positioned to 6 cm above the squamo-columnar junction. Patients encouraged to maintain normal activity and diet, and kept a diary of diet sleep and symptoms for 7 days. Mean age: 44 years, male = 42%, GORD symptoms on PPI = 45%, Pre-op evaluation = 43%, failed transnasal monitoring = 7%, extra-oesophageal GORD = 5%. Mean follow-up: 7 days Disclosure of interest: not stated.	**Operative success** Placement of the wireless catheter was achieved in 95% (80/84) of patients. Premature (< 48 hours) capsule detachment occurred in 4% (3/80) of these patients. No difficulties with data retrieval from monitors were reported. Chest X-ray at 7 days showed all capsules had detached from the oesophagus. **pH measurement** Median / mean time / events over 2 days of recording Outcome / Day 1 / Day 2 / p value % time pH < 4 / 5.5 / 5.7 / N/S Supine % time pH < 4 / 1.4 / 0.66 / N/S Upright % time pH < 4 / 5.9 / 6.0 / N/S Reflux events / 45.3 / 65.0 / 0.004 Reflux events > 5 minutes / 4.2 / 3.05 / N/S	**Complications** Symptoms relating to capsule attachment: 80% (64/80) Chest pain: 33% (26/80) Foreign body sensation: 14% (11/80) Multivariate analysis found age (p=0.005), and gender (0.009) to be significant independent predictors of developing symptoms, with younger age and female gender being more prevalent in the group that reported symptoms.	Well-expressed methods used for logistic regression. Comparison of day-to-day reflux not analysed in relation to diet or activity. No independent assessment of outcome. Patient population includes some patients investigated for GORD and some for post-therapy evaluation. Patients referred to study but given choice to participate. Some data rounded to one decimal place, some to two places.

Abbreviations used: GI, gastrointestinal; GORD/GERD, gastro-oesophageal reflux disease; PPI, proton pump inhibitor; QOL, quality of life.			
Study details	**Key efficacy findings**	**Key safety findings**	**Comments**
Ward E M (2004)[6] Case series USA n = 60 Consecutive patient cohort 48 hours of monitoring with Bravo capsule positioned endoscopically to 6 cm above the squamo-columnar junction. Patients encouraged to maintain normal activity and diet. Mean age: 54 years, male =43%, pre-surgery GORD n = 14, possible GORD with negative PPI trial n = 21, possible supra-oesophageal GORD n = 6, non-cardiac chest pain n = 9, failed previous pH test n = 1, evaluating response to PPI therapy n = 5, evaluating response to surgery n = 4. Mean follow-up: 2 days Disclosure of interest: not stated.	**Operative success** Adequate studies were possible in 97% (58/60) of patients The capsule failed to attach to the oesophageal mucosa on the first attempt in 12% (7/60) of patients. In one patient a second attempt failed and the procedure was abandoned. In 2% (1/60) of patients data was irretrievable from the monitor. **pH measurement** There was a positive result indicating GORD in 93% (13/14) patients having in investigation before surgery.	**Complications** 'A few' patients reported feeling a 'foreign body' or other chest discomfort. No patients requested removal of the wireless capsule.	Series represents initial experience with the system at one centre. Patient population includes some patients investigated for GORD and some for post-therapy evaluation. Six patients also underwent colonoscopy during the same endoscopic session. No raw data on reflux episodes is reported. Only GORD-positive assessment.

Abbreviations used: GI, gastrointestinal; GORD/GERD, gastro-oesophageal reflux disease; PPI, proton pump inhibitor; QOL, quality of life.

Study details	Key efficacy findings	Key safety findings	Comments
Hochman J A (2005)[7] Case series USA n = 44 (children) Consecutive cases June 2004 to December 2004 48 hours of monitoring with Bravo capsule positioned endoscopically to 6 cm above the proximal border of the lower oesophageal sphincter. Medication that could alter pH results were discontinued at least 48 hours before the study Mean age =12 years (range 6 to 19), Male =61% FU = 2 days Disclosure of interest not stated	**Test reproducibility** A test was considered reproducible if a either a normal or abnormal gastro-oesophageal reflux index was recorded on both days of monitoring The pathological reflux index was in agreement on the 2 days in 77% (34/44) of patients. 25% (11/44) of patients had a pathological reflux on both days Parameter / Day 1 / Day2 / P value Number of reflux episodes / 28 / 22 / 0.99 Reflux time (<pH4) (minutes) / 54.5 / 31 / 0.01 **Device acceptability** 94% (36/38 of parents questioned were willing to allow their child to undergo wireless pH monitoring in the future, and all 12 patients who had previously had nasal-catheter monitoring preferred the wireless method.	**Complications** outcome: incidence Discomfort: 68% (26/38) Significant discomfort: 18% (7/38) Pain requiring emergency room visit: 3% (1/38)	Patients who had changes in medication or diet during the course of pH monitoring were excluded from the study Not stated whether these patients were the first to be treated at the centre of whether the investigators were experienced in the procedure 12% (6/50) of patients initially enrolled could not be analysed. 4 had monitoring of less than 36 hours, 1had a change in medication during the study, and in 1 the capsule failed to attach correctly. Some degree of day to day variation in reflux pattern is to be expected. No details of blinding of outcome assessors.

Validity and generalisability of the studies

- One device used in all studies.
- Some studies used healthy controls whereas others used those with GORD symptoms.
- No data of specificity or sensitivity compared with gold standard of nasal catheter pH monitoring.
- Few controlled studies and some study designs provide meaningless outcomes.

Specialist advisors' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College.

Mr T C B Dehn, Professor J Jankowski, Dr S A Riley, Dr N J Trudgil

- This procedure requires an endoscopy which is usually clinically unnecessary.
- Catheterless oesophageal pH monitoring may provide accurate recording under conditions of normal daily activity with less discomfort than a catheter-based system.
- The advisors were split in their consideration of the current status of the procedure, with one regarding it as a minor variation of an established procedure, two that it is novel and of uncertain safety and efficacy, and one that it was the first in a new class of procedure.
- Reported adverse events include chest discomfort, mucosal tear, failure of the capsule to detach and failure of data retrieval.
- Additional theoretical complications may include haemorrhage, oesophageal perforation, oesophageal ulceration, capsule misplacement and failure to pass the capsule once detached.
- Relatively little training is required for an experienced endoscopist.
- Audit criteria for the procedure should include 48 recordings, chest pain, incidence of requirement for removal of the capsule, failure of the capsule to detach, retention of the capsule, bleeding and data loss.
- The advisors were divided on how many centres are likely to offer this procedure, and it will depend on whether it is shown to be more accurate than standard catheter monitoring. However, most major GI units will provide this technique.

Issues for consideration by IPAC

- The wireless monitoring system can be used for diagnosis, or for evaluating treatment success.
- The utility of oesophageal pH monitoring in the diagnosis and management of GORD is currently uncertain.
- There is some uncertainty about the epidemiology and natural history of GORD disease in adults.

References

1 Wong WM, Bautista J, Dekel R et al. (2005) Feasibility and tolerability of transnasal/per-oral placement of the wireless pH capsule vs. traditional 24-h oesophageal pH monitoring--a randomized trial. *Alimentary Pharmacology & Therapeutics* 21:155-63.

2 des Varannes SB, Mion F, Ducrotte P et al. (2005) Simultaneous recordings of oesophageal acid exposure with conventional pH monitoring and a wireless system (Bravo). *Gut* 54:1682-6.

3 Pandolfino JE, Zhang Q, Schreiner MA et al. (2005) Acid reflux event detection using the Bravo wireless versus the Slimline catheter pH systems: why are the numbers so different? *Gut* 54:1687-92.

4 Pandolfino JE, Richter JE, Ours T et al. (2003) Ambulatory esophageal pH monitoring using a wireless system. *American Journal of Gastroenterology* 98:740-9.

5 Remes-Troche JM, Ibarra-Palomino J, Carmona-Sanchez RI et al. (2005) Performance, tolerability, and symptoms related to prolonged pH monitoring using the Bravo system in Mexico. *American Journal of Gastroenterology* 100:2382-6.

6 Ward EM, DeVault KR, Bouras EP et al. (2004) Successful oesophageal pH monitoring with a catheter-free system. *Alimentary Pharmacology & Therapeutics* 19:449-54.

7 Hochman JA, Favaloro-Sabatier J (2005) Tolerance and reliability of wireless pH monitoring in children. Journal of Pediatric Gastroenterology and Nutrition 41(4):411−5.

Appendix A: Additional papers on catheterless oesophageal pH monitoring not included in summary Table 2

The following table outlines the studies that are considered potentially relevant to the overview but were not included in the main data extraction table (Table 2). It is by no means an exhaustive list of potentially relevant studies.

Article title	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in Table 2
Belafsky PC, Allen K, Castro-Del Rosario L et al. (2004) Wireless pH testing as an adjunct to unsedated transnasal esophagoscopy: the safety and efficacy of transnasal telemetry capsule placement. *Otolaryngology and Head and Neck Surgery* 131(1):26−8.	n = 46 FU=?	85% (39/46) of procedures were successful.	Only 18 of 46 patients had GORD. Bigger case series are included in Table 2.
Bothwell M, Phillips J, Bauer S (2004) Upper esophageal pH monitoring of children with the Bravo pH capsule. *Laryngoscope* 114(4):786−8.	n = 30 (children) FU = 2 days	97% (29/30) of patients were successfully tested. A minor mucosal injury was caused by inadvertent capsule extraction in one patient.	Bigger case series are included in Table 2.
Tu CH, Lee YC, Wang HP et al. (2004) Ambulatory esophageal pH monitoring by using a wireless system: a pilot study in Taiwan. *Hepatogastroenterology* 51(60):1586−9.	n = 25 FU = ?	No serious complications were reported. In one patient there was difficulty in capsule deployment.	Bigger case series are included in Table 2.

Appendix B: Related published NICE guidance for catheterless oesophageal pH monitoring

Guidance programme	Recommendation
Interventional procedures	None applicable
Technology appraisals	None applicable
Clinical guidelines	Dyspepsia: management of dyspepsia in adults in primary care. *NICE clinical guideline* no. 17 1.2.4 Urgent specialist referral or endoscopic investigation* is indicated for patients of any age with dyspepsia when presenting with any of the following: chronic gastrointestinal bleeding; progressive unintentional weight loss; progressive difficulty swallowing; persistent vomiting; iron deficiency anaemia; epigastric mass or suspicious barium meal. * The Guideline Development Group considered that 'urgent' meant being seen within 2 weeks. 1.2.5 Routine endoscopic investigation of patients of any age presenting with dyspepsia and without alarm signs is not necessary. However, in patients aged 55 years and older with unexplained and persistent recent-onset dyspepsia alone, an urgent referral for endoscopy should be made.
Public health	None applicable

Appendix C: Literature search for catheterless oesophageal pH monitoring

Procedure number: 314	Procedure name: Catheterless oesophageal pH monitoring	
Databases	**Version searched (if applicable)**	**Date searched**
The Cochrane Library	2005 Issue 4	28/12/2005
CRD	December 2005	28/12/2005
Embase	1980 to 2005 Week 52	28/12/2005
Medline	1966 to November Week 3 2005	28/12/2005
Premedline	December 27, 2005	28/12/2005
CINAHL	1982 to December Week 2 2005	28/12/2005
British Library Inside Conferences (limited to current year only)	1993 to date	28/12/2005
National Research Register	2005 Issue 4	29/12/2005
Controlled Trials Registry	N/A	28/12/2005

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in other databases.

1	catheter free.tw.
2	catheterless.tw.
3	(wireless or tubeless).tw.
4	telemetry.tw.
5	TELEMETRY/
6	radio transmit$.tw.
7	radio transmis$.tw.
8	radiotransmit$.tw.
9	radiotransmis$.tw.
10	or/1-9
11	(ph adj2 monitor$).tw.
12	MONITORING, PHYSIOLOGIC/
13	Hydrogen-Ion Concentration/
14	Gastric Acidity Determination/
15	or/11-14
16	10 and 15
17	bravo.tw.
18	16 or 17
19	ESOPHAGUS/
20	(oesophag$ or esophag$).tw.
21	intragastric$.tw.
22	or/19-21
23	18 and 22
24	Animals/
25	Humans/
26	24 not (24 and 25)
27	23 not 26