

Photodynamic therapy for dysplastic Barrett's oesophagus: a prospective, double blind, randomised, placebo controlled trial

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Abstract

Background and aims—Photodynamic therapy (PDT) is a treatment in which cell damage is achieved by the action of light on a photosensitising agent. We have assessed the potential use of PDT in the ablation of Barrett's oesophagus.

Methods—Thirty six patients with dysplastic Barrett's oesophagus receiving acid suppression medication with omeprazole were randomised to receive oral 5-aminolaevulinic acid (ALA) 30 mg/kg or placebo, followed four hours later by laser endoscopy. Follow up endoscopy was performed at one, six, 12, and 24 months.

Results—Of 18 patients in the ALA group, a response was seen in 16 (median decrease in area in the treated region 30%; range 0–60%). In the placebo group, a decrease in area of 10% was observed in two patients with no change in 16 (median 0%; range 0–10%; treatment *v* placebo, $p < 0.001$). No dysplasia was seen in the columnar epithelium within the treatment area of any patient in the PDT group. However, in the placebo group, persistent low grade dysplasia was found in 12 patients ($p < 0.001$). There were no short or long term major side effects. The effects of treatment were maintained for up to 24 months.

Conclusions—This is the first randomised controlled trial of PDT for Barrett's oesophagus. It demonstrates that ALA induced PDT can provide safe and effective ablation of low grade dysplastic epithelium.

(Gut 2000;47:612–617)

Keywords: Barrett's oesophagus; photodynamic therapy; aminolaevulinic acid; protoporphyrin IX

The incidence of oesophageal adenocarcinoma is rapidly increasing in the western world. A major risk factor is Barrett's oesophagus, an acquired condition in which squamous mucosa is replaced by metaplastic columnar epithelium. The incidence has been estimated as 1 in 52 to 1 in 441 patient years.^{1–3} The risk is increased with dysplasia; in particular, high grade dysplasia (HGD) is considered a precursor of malignancy, and therefore an indication for oesophagectomy in suitable patients.^{3,4}

Current therapeutic approaches aim to decrease oesophageal acid exposure by pharmacological or surgical means. However,

despite the efficacy of medical treatment in symptom control and ulcer healing, there is little evidence that it produces regression of Barrett's epithelium. Results of antireflux surgery demonstrate regression in 40% of patients in one study,⁵ and squamous island formation in another,⁶ but others failed to show any regression.^{7–9}

Another approach is photodynamic therapy (PDT) which involves administration of a photosensitising drug followed by application of light to produce cell damage. The most commonly used photosensitiser is haematoporphyrin derivative (HpD), which has been used in the treatment of early dysplasia and carcinoma in Barrett's oesophagus, although treatments have been complicated by stricture formation due to excess depth of tissue damage.¹⁰ Overholt reports the use of PDT using sodium porphyrin and red light in the treatment of 100 patients with dysplasia and superficial carcinoma in Barrett's oesophagus.¹¹ Mucosal ablation and squamous re-epithelialisation was seen in 75–80% of treated Barrett's mucosa, with complete elimination in 43 cases. Areas of dysplasia were eliminated in 78 patients and 10 of 13 malignancies were ablated. However, healing was associated with stricture formation in 34%.

A novel approach to PDT is endogenous photosensitisation with aminolaevulinic acid (ALA), a naturally occurring compound in the haem biosynthetic pathway. This has no innate photosensitising properties but is metabolised to the photosensitive compound protoporphyrin IX (PpIX). This has several advantages over HpD, in particular a reduced duration of photosensitisation and an affinity for epithelial tissues. This results in a more selective effect in the gastrointestinal mucosa, with less damage to underlying muscle thus reducing the risk of stricture and/or perforation.

ALA induced PDT has been used in the treatment of both dysplastic Barrett's oesophagus and oesophageal carcinoma.^{12–14} In a report of five patients with HGD in Barrett's oesophagus treated with ALA induced PDT, elimination of HGD and squamous regeneration was seen in all patients. There were no complications or recurrence of dysplasia after

Abbreviations used in this paper: PDT, photodynamic therapy; ALA, aminolaevulinic acid; LGD, low grade dysplasia; HGD, high grade dysplasia; HpD, haematoporphyrin derivative; PpIX, protoporphyrin IX; Nd-YAG, neodymium-yttrium aluminium garnet; KTP, potassium titanyl phosphate; MPEC, multipolar electrocoagulation; ABPC, argon beam plasma coagulation.

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Accepted for publication 9 May 2000

26–44 months of follow up but in two cases persistent non-dysplastic columnar glands were found beneath the neo-squamous epithelium.¹³

More recently, in a report of 32 patients with HGD (n=10) or mucosal cancer (n=22) in Barrett's oesophagus treated with ALA induced PDT, dysplasia was eradicated in all patients (10 of 10) and mucosal cancer in 17 of 22 (77%) at a mean follow up of 9.9 (range 1–30 months). All tumours up to 2 mm in depth were completely ablated (17 of 17). There was no morbidity or mortality.¹⁴

While these studies demonstrate the feasibility of ALA induced PDT as treatment for Barrett's oesophagus, they are uncontrolled series and there have been no randomised controlled trials. This study aimed to assess the efficacy of PDT in the ablation of Barrett's oesophagus in a prospective, double blind, randomised, placebo controlled trial with observer blinded endoscopic and histological assessment of treatment response. The trial aimed to exclude placebo response due to laser light related hyperthermia or the effect of drug alone (omeprazole or ALA), and to eliminate avoidable sources of bias, such as observer error. We assessed not only the macroscopic effect on Barrett's mucosa but also the histological effects on dysplasia and the issue of "buried" glands seen in other studies, and attempted to establish the duration of treatment response. Treatment parameters were those established in a previous pharmacokinetic study of PpIX production after two different oral doses of ALA at three different time points.^{15 16}

Patients and methods

After ethics committee approval was obtained, appropriate patients were sought from endoscopy and histopathology records. Patient recruitment took place throughout 1995, and eligibility was restricted to patients with low grade dysplasia (LGD) in circumferential Barrett's oesophagus of at least 3 cm in length who were receiving omeprazole. Patients were identified and the histology was re-examined by a single experienced gastrointestinal histopathologist (TJS) to confirm the diagnosis. Barrett's oesophagus was diagnosed only when specialised columnar epithelium (with intestinal metaplasia) was seen.¹⁷ Dysplasia was defined as neoplastic epithelium confined within the basement membrane in the absence of inflammation, and was classified as LGD according to accepted criteria.^{17 18} The histological diagnosis was confirmed on biopsy, no more than six weeks before treatment.

TREATMENT PROTOCOL

All treatments were performed as day cases. Patients were randomised to receive 30 mg/kg ALA or placebo. The randomisation was performed 1:1 by opening of one of a series of 36 previously sealed envelopes. This was done by pharmacy staff and the outcome was unknown to clinical staff and patients. ALA was dissolved in 50 ml of orange juice or placebo was provided (orange juice alone). ALA is tasteless and so the treatment group

could not detect the drug in their drink. Four hours after ALA or placebo administration, laser endoscopy was performed under intravenous sedation and analgesia (midazolam, pethidine, and propofol) administered by an anaesthetist. ALA dose and interval between ALA and light administration were selected on the basis of a previous dosimetric study.^{15 16}

Once the patient was sedated, endoscopy was performed using an Olympus Q10 endoscope (Olympus Optical Co. Ltd, Tokyo, Japan). At this time, the length and percentage of the circumference of the oesophageal wall covered by Barrett's columnar epithelium was recorded, from which the area involved was calculated. All longitudinal measurements were taken from the upper incisor teeth (or gum) and confirmatory photographs were taken.

Laser light was generated by a copper vapour laser (Oxford 20 Watt, Oxford Lasers, Abingdon, UK) and delivered via a fibre with a diffuser tip (Laserscope Flex Cylinder Diffuser, PDT Systems Inc., Santa Barbara, California, USA). Uniform oesophageal light distribution was achieved using an applicator, consisting of a 14 mm diameter clear perspex cylinder attached to the end of an Atkinson tube introducer with a central channel 3 cm in length, housing the diffuser tip of the laser fibre. Before and after treatment, the light delivery system was calibrated using an integrating sphere, and throughout treatment light delivery was monitored by means of an isotropic detector fibre incorporated in the applicator.

The light applicator was lubricated and introduced over an endoscopically positioned guidewire into the oesophagus. It was positioned by means of 1 cm calibrated markings along the outer sheath so that the 3 cm "treatment window" was situated at the area of the oesophagus to be treated, as determined by measurement from the incisor teeth (or gums). Because of the size of the introducer it was not possible to check endoscopically the position of the light delivery system under direct vision.

All patients were treated with green light (514 nm) at a power density of 120 mW/cm² for a period of 500 seconds per 3 cm length. Temperature was monitored by a thermocouple in the applicator. Each therapy consisted of two separate treatments (distal then proximal; total treatment time 1000 seconds; energy density 60 J/cm²) so that a total of 6 cm (2×3cm) length of oesophagus was treated, coinciding with the upper 6 cm of Barrett's mucosa. A 6 cm treatment represented complete treatment of Barrett's epithelium in 18 of 36 (50%) patients.

If the Barrett's segment was between 3 and 6 cm, two treatments were still performed. If tongues of columnar epithelium were observed above the area of circumferential Barrett's, the area to be treated was measured from the apex. This led to some areas of normal mucosa being included in the treatment area but this was necessary for complete treatment of the 6 cm length of Barrett's. If the length of Barrett's oesophagus was greater than 6 cm, no further

treatment was performed and any residual disease was left untreated. This was because the combination of the inflexibility and diameter of the introducing system and duration of treatment required to treat longer segments was considered inappropriate, particularly as the aim of the study was to study the effect of PDT rather than totally eradicate all traces of Barrett's oesophagus.

Following treatment, patients were given analgesia and antiemetics as required and were allowed to eat and drink as soon as they were able. They remained in hospital until dark and were then allowed home, with appropriate oral analgesia and a supply of antacids to take as necessary. Patients were advised to avoid bright light for 24 hours.

FOLLOW UP PROTOCOL

Throughout treatment and the whole of the follow up period (two years), patients were maintained on omeprazole 20 mg daily. Follow up endoscopic assessments were performed at one, six, 12, and 24 months after treatment. The length and percentage of the involved circumference were recorded, from which the area was calculated.

At each visit, endoscopy was performed by two independent observers, neither of whom was aware of the patient's randomisation group, and both were blinded to the pretreatment assessment and to each other's assessment. Subsequent comparisons were made between the pre- and post-treatment assessments, and the two post-treatment assessments, from which the effect of treatment and degree of interobserver variation in endoscopic interpretation of Barrett's oesophagus was assessed. In each patient, the percentage change in area was recorded to the nearest 10%, as it is not possible to quantify this to any greater degree. Only on final statistical analysis was the mean percentage area reduction calculated to the nearest 1%.

Six biopsies were taken from the treated area for histological analysis at six, 12, and 24 months to confirm whether true regression from columnar to squamous epithelium had occurred and to assess the impact on dysplasia and the presence of buried glands. The biopsies were taken using standard endoscopic biopsy forceps and sent for histological analysis.

Sections were stained with haematoxylin and eosin and examined both by the routine hospital histopathology service and again by a single experienced gastrointestinal histopathologist (TJS) who was blinded to the other histological analyses and to the randomisation group of the patient.

STATISTICAL ANALYSIS

Before patients were recruited, a power calculation was performed using a commercially available software package (In Stat, Version 2.01, Graph Pub Software, San Diego, California, USA). It was calculated that to show a 30% difference in outcome (as predicted from previous open studies) at a significance level (two sided) of $p < 0.05$ and a power of 90%, 16 patients would be required in each group.

Patient demographics and pretreatment findings were analysed using either a χ^2 or two tailed Mann-Whitney U test, as appropriate. The outcome of treatment was analysed in two ways. Both the proportion of responders and mean percentage of area regression were calculated for each of the two groups. Statistical analysis was performed using the SPSS for Windows (version 6.0) software package. To compare the proportion of patients responding in each group, a 2×2 comparison was made using a χ^2 test. The percentage area regression was assessed by two tailed Mann-Whitney U test. Statistical significance was taken at $p < 0.05$.

Results

Of 70 patients initially thought to have LGD in Barrett's, the diagnosis was confirmed in 45 on expert pathology review. Of these, 36 patients (30 male, six female; median age 56 (range 30–71) years) agreed to enter the study, of whom 18 were given 30 mg/kg ALA and 18 received placebo. The two groups were demographically similar, with 15 men and three women in each and a median age of 56 (range 30–71) and 54 (range 44–68) years, respectively. Both had similar pretreatment lengths of Barrett's, with a median total length of 6 cm (range 4–15) and 7 cm (range 3–15), respectively (tables 1, 2). Nine patients refused to take part in the study, five for family reasons and four claiming that they wished to see that

Table 1 Demographic details and treatment outcome in patients who received aminolaevulinic acid-photodynamic therapy

Patient No	Sex	Age (y)	Pretreatment endoscopy findings	Post-treatment endoscopy findings	Post-treatment histology	Percentage area regression
1	M	63	9 cm circumferential Barrett's	7 cm circumferential Barrett's	Normal squamous	30
2	F	30	6 cm circumferential Barrett's	5 cm streaky Barrett's	Normal squamous	50
3	M	52	6 cm circumferential Barrett's	4 cm Barrett's with islands++	Normal squamous	50
4	M	58	13 cm circumferential Barrett's	13 cm Barrett's with islands	Squamous/ Barrett's	10
5	M	49	6 cm circumferential Barrett's	2 cm Barrett's + 3 cm streaks	Normal squamous	60
6	M	54	6 cm Barrett's + 1 cm tongue	6 cm circumferential Barrett's	Squamous / Barrett's	10
7	M	53	14 cm Barrett's + 1 cm tongue	13 cm Barrett's + 2 cm tongue	Normal squamous	10
8	M	58	4 cm Barrett's + 1 cm tongue	3 cm Barrett's + 2 cm streaks	Normal squamous	40
9	F	71	4 cm Barrett's + some islands	3 cm Barrett's + islands++	Normal squamous	30
10	M	53	4 cm Barrett's + 1 cm tongue	3 cm Barrett's + 2 cm tongue	Normal squamous	30
11	M	64	6 cm circumferential Barrett's	4 cm Barrett's + 2 cm tongue	Normal squamous	30
12	M	54	4 cm Barrett's + 1 cm tongue	2 cm Barrett's + 2 cm tongue	Normal squamous	50
13	M	69	10 cm Barrett's + 2 cm tongue	10 cm Barrett's + 2 cm tongue	Barrett's; no dysplasia	0
14	M	67	3 cm Barrett's + 2 cm tongue	3 cm Barrett's + 2 cm tongue	Barrett's; no dysplasia	0
15	M	52	7 cm Barrett's + 2 cm tongue	6 cm Barrett's + 2 cm tongue	Normal squamous	10
16	M	63	14 cm Barrett's + some islands	11 cm Barrett's + 4 cm streaks	Normal squamous	50
17	M	54	7 cm Barrett's + 2 cm tongue	5 cm Barrett's + 2 cm tongue	Normal squamous	40
18	F	59	2 cm Barrett's + 3 cm streaks	4 cm streaky Barrett's	Normal squamous	60

Table 2 Demographic details and treatment outcome in patients who received placebo

Patient No	Sex	Age (y)	Pretreatment endoscopic findings	Post-treatment endoscopic findings	Post-treatment histology	Percentage area regression
1	M	65	6 cm circumferential Barrett's	6 cm circumferential Barrett's	Barrett's with LGD	0
2	M	64	10 cm circumferential Barrett's	10 cm circumferential Barrett's	Barrett's with LGD	0
3	M	50	5 cm circumferential Barrett's	5 cm circumferential Barrett's	Barrett's; no dysplasia	0
4	M	68	10 cm circumferential Barrett's	10 cm circumferential Barrett's	Barrett's with LGD	0
5	M	60	10 cm Barrett's + 2 cm tongue	9 cm Barrett's + 3 cm tongue	Barrett's with LGD	10
6	M	44	13 cm Barrett's + 1 cm tongue	13 cm Barrett's + 1 cm tongue	Barrett's; no dysplasia	0
7	M	64	2 cm Barrett's + 2 cm tongue	2 cm Barrett's + 2 cm tongue	Barrett's; no dysplasia	0
8	M	50	7 cm Barrett's + 2 cm streaks	7 cm Barrett's + 2 cm streaks	Barrett's with LGD	0
9	M	48	8 cm Barrett's + 1 cm streaks	8 cm Barrett's + 1 cm streaks	Barrett's with LGD	0
10	F	63	3 cm Barrett's + 2 cm streaks	2 cm Barrett's + 3 cm streaks	Barrett's with LGD	10
11	M	42	11 cm Barrett's + 1 cm streaks	11 cm Barrett's + 1 cm streaks	Barrett's with LGD	0
12	M	67	6 cm circumferential Barrett's	6 cm circumferential Barrett's	Barrett's; no dysplasia	0
13	M	51	13 cm Barrett's + 2 cm streaks	13 cm Barrett's + 2 cm streaks	Barrett's with LGD	0
14	M	48	5 cm Barrett's + 1 cm streaks	5 cm Barrett's + 1 cm streaks	Barrett's with LGD	0
15	M	57	2 cm Barrett's + 1 cm streaks	2 cm Barrett's + 1 cm streaks	Barrett's with LGD	0
16	M	48	6 cm Barrett's + 1 cm streaks	6 cm Barrett's + 1 cm streaks	Barrett's with LGD	0
17	F	48	3 cm Barrett's + 2 cm tongue	3 cm Barrett's + 2 cm tongue	Barrett's; no dysplasia	0
18	F	68	7 cm circumferential Barrett's	7 cm circumferential Barrett's	Barrett's; no dysplasia	0

LGD, low grade dysplasia.

the treatment was effective before agreeing to undergo several endoscopic examinations.

Of the 18 patients given photosensitiser, 16 (89%) showed macroscopic evidence of regression at follow up endoscopy. The median reduction in area within the treated area was 30%. Of the patients given placebo, a macroscopic response was seen in two (11%). In these, the area regression was 10%, producing an overall median response of 0% regression (tables 1, 2). There was a statistically significant difference between the two groups (treatment *v* placebo) in the number of patients responding ($\chi^2=21.8$; df 1, $p<0.001$, difference in proportions 78%, 95% confidence interval (CI) 56–100%) and in median area regression (median area difference 30%, 95% CI 20–40%; $p<0.001$).

Histological examination of the biopsies taken at follow up endoscopy confirmed the macroscopic findings in all cases. In all 16 cases of regression in the treatment group, biopsies from the area of re-epithelialisation displayed normal squamous mucosa, with no evidence of either squamous dysplasia or underlying columnar epithelium. Moreover, biopsies of the remaining columnar epithelium in all 18 cases displayed no evidence of dysplasia in the area that had been treated with PDT. In the placebo group, biopsies from the area of re-epithelialisation in the two cases showing some evidence of regression confirmed the appearance of normal squamous epithelium. Biopsies from the apparently unchanged columnar epithelium displayed Barrett's columnar mucosa in all cases. In 12 of 18 cases, there was persistent LGD but in six patients no evidence of dysplasia was seen (tables 1, 2). With regard to the effect on dysplasia alone, there was therefore a statistically significant difference between the two groups ($\chi^2=18.0$; df 1, $p<0.001$). In all cases, the underlying submucosa was identified, confirming that the biopsies taken represented full thickness samples.

SIDE EFFECTS

All 18 patients in the ALA treatment group experienced pain in the chest during the treatment (associated with restlessness and tachycardia). This discomfort persisted for 3–5 days following treatment and was aggravated by

swallowing or coughing. However, only three patients required analgesia. One patient developed a mild skin rash after exposure to sunlight on the day after treatment. This resolved within 48 hours without the need for treatment. No patient complained of dysphagia at any stage following treatment.

FOLLOW UP ASSESSMENT

The interobserver variation in assessment of the area of Barrett's epithelium at the one month follow up endoscopy by the two independent observers was within 10% in 35 of 36 cases and differed by 30% in one case. Endoscopic assessments at six, 12, and 24 months after treatment were compatible within 10% in all cases to those at the one month assessment, with responses maintained over the 24 month follow up period. There were no cases of further progression or regression of the columnar epithelium or dysplasia in either group.

Discussion

When the present study was designed and implemented (1995), there were no published reports of the effect of ALA-PDT on Barrett's oesophagus. Therefore, we designed a double blind, randomised, placebo controlled trial to address this question. We did not aim to ablate all of the area of Barrett's change in every case for the following reasons:

- (i) treatment of segments greater than 6 cm was considered inappropriate because of prolonged treatment times (>16 minutes) due to the unsuitability of the introducing system used in this study. At this time, there was no commercially available balloon catheter;
- (ii) confirmation that ALA-PDT is effective and safe in the ablation of Barrett's oesophagus in this type of study could be used to justify further studies designed to completely eradicate the Barrett's change, using a combination of longer flexible balloon devices and retreatment of unaffected areas. There are now several reports in the literature demonstrating the efficacy of ALA-PDT in the treatment of dysplastic Barrett's oesophagus.^{13 14} However, the current study remains the only

prospective, randomised, controlled study to date using treatment parameters established in a previous pharmacokinetic study.^{15 16}

We demonstrated a significant difference between treatment and control groups in all parameters examined. There was a highly significant difference in the proportion of patients responding to treatment, with 90% and 10% responses in the treatment and control groups, respectively. There was also a significant reduction in columnar epithelial area in the treatment group. The reduction of Barrett's by only 30% of the treatment area and the patchy response within the treatment area in some patients could be seen as a weakness of the study. However, as previously stated, we did not aim to completely ablate the Barrett's change in all cases.

In most cases, PDT resulted in streaks or patches of columnar epithelium rather than complete circumferential ablation. The reason for this is unclear, but it may be due to the use of a solid state applicator with a fixed external diameter. The internal luminal diameter of the oesophagus varies within and between patients and is convoluted unless expanded. The streaks and patches of columnar epithelium remaining may be due to mucosal folds not eradicated by the applicator. Another disadvantage is the diameter of the applicator used in this study, requiring sedation for the introduction of the device. Oesophageal intubation would be easier with a more flexible device, which could be passed via the biopsy channel of an endoscope. The latter may also allow more accurate placement within the oesophagus, with less reliance on measurement of the distance from the incisor teeth, also permitting direct visualisation during treatment. The use of a balloon catheter may solve these problems, but such devices were not readily available at the onset of the study in 1995. Thus complete ablation of Barrett's oesophagus may be achieved far more readily using a combination of balloon light delivery devices, multiple treatments at each session, and repeated treatment sessions. The effect of increased doses of proton pump inhibitors should also be studied as this may account for some of the response seen in regression of Barrett's change and dysplasia in the placebo group.

Dysplasia was successfully eliminated in the treated area in the PDT group, including the two cases showing no obvious macroscopic response, while in the placebo group LGD persisted in two thirds of cases. The reason for the apparent elimination of dysplasia in one third of patients in the placebo group is unclear. It may have been due to continuing administration of omeprazole throughout treatment or to the natural history of LGD which can spontaneously regress in some cases. Indeed, it could be argued that it would be better to perform a trial such as this using only patients with HGD, but such patients are less common and would be harder to recruit. Equally, it may have been a sampling error at the time of the biopsy, with Barrett's epithelium containing only patchy dysplastic

changes. At the time of planning this study, the value of systematic four quadrant biopsies in preference to multiple "random" biopsies was not recognised. However, despite the theoretical limitation of the biopsy regimen in the current study, dysplasia was detected in all patients before treatment and none after treatment in the PDT group. There was a significant difference between the two groups, indicating that ALA-PDT may cause regression of dysplasia without necessarily eradicating the associated Barrett's change. This unexpected finding has not been reported previously and requires further confirmation in future studies.

This trial confirmed the efficacy of ALA induced PDT in the treatment of dysplastic Barrett's oesophagus, the results in the treatment group being similar to those of other series.^{13 14} A major drawback of treatment seen in previous studies has been the persistence of buried columnar glands beneath the neo-squamous epithelium, with consequent implications for the remaining cancer risk.¹³ This was not encountered in our study. The reason for this may be due to the use of green light which, although it penetrates mucosa less well than red light, is entirely absorbed within the depth corresponding to the mucosa, possibly resulting in a greater PDT effect.¹⁹ Alternatively, it could be sampling error, but this is unlikely given that each patient had six biopsies on four occasions after treatment.

PDT is not the only form of ablative therapy currently under investigation for the treatment of Barrett's oesophagus. Thermal photocoagulation using neodymium-yttrium aluminium garnet (Nd-YAG)²⁰ or potassium titanyl phosphate (KTP)^{21 22} laser, multipolar electrocoagulation (MPEC),²³ and argon beam plasma coagulation (ABPC)²⁴ have been reported. In a report of 16 patients with non-dysplastic Barrett's oesophagus treated by KTP laser and acid suppression, mucosal ablation and squamous regeneration were seen in all cases.²¹ However, in 11 patients there was evidence of squamous regeneration over remaining Barrett's glands, and in nine patients squamous metaplasia was seen within Barrett's glands. In another study of 10 patients with Barrett's, complete mucosal ablation was achieved in all cases, but specialised mucosa was seen beneath the neo-squamous epithelium.²² In a report of 24 patients with Barrett's oesophagus (six with dysplasia) treated with ABPC, complete replacement of Barrett's mucosa by squamous epithelium was achieved in 13.²⁴ However, these results were achieved with repeated treatments (median 2; range 1-7). Furthermore there were two oesophageal perforations (one fatal), a problem not seen in the present study.

Further studies are required to improve the efficacy of ALA induced PDT. The use of a balloon catheter may improve clinical outcome by eliminating folds in the oesophageal mucosa thereby improving intraoesophageal light distribution. This study has demonstrated that the treatment is safe and simple to perform. In light of this, a protocol of multiple treatments

with the end point of producing complete ablation is required. Finally, randomised, placebo controlled clinical trials are needed to study the use of all types of ablative therapy and there will eventually be a need for prospective randomised trials to compare these different techniques.

This is the first prospective, double blind, randomised, placebo controlled trial of PDT to show effective ablation of dysplastic Barrett's oesophagus. It was a rigorous and unbiased assessment of this therapy and provides a clear indication of its potential. The majority of patients given photosensitiser and light showed evidence of macroscopic improvement following treatment, and in all cases there was apparent elimination of dysplasia. In contrast with other ablative therapies, or PDT with porphyrin based sensitisers, the low risk of complications renders this a viable treatment for dysplastic and possibly non-dysplastic Barrett's oesophagus.

This work was supported by a research grant from Trent Regional Health Authority. The authors wish to thank numerous clinical collaborators, including Mr A J Shorthouse, Dr K D Bardhan, Dr A J Lobo, and Dr D C Gleeson. Thanks to Dr J E Peacock for anaesthetic support, and to the staff of the Day Case Unit, Endoscopy Unit and Pharmacy Manufacturing Unit at the Royal Hallamshire Hospital, Sheffield for all their help and time spent assisting in this work.

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