RESEARCH

Nitrous oxide use during colonoscopy: a national survey of English screening colonoscopists

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ABSTRACT

Introduction Nitrous oxide can improve patient experience during colonoscopy, and its rapid elimination minimises after effects and inconvenience. Despite its advantages, nitrous oxide is used infrequently in the UK. We sought to understand the reasons for its low use.

Methods Colonoscopists within the English Bowel Cancer Screening Programme (BCSP) were invited to participate in a web-based survey assessing the availability, current practices and perceptions towards nitrous oxide. Respondents were able to select predefined answers or offer written responses. Free text responses were assessed using thematic analysis.

Results The survey was completed by 68% of the English BCSP colonoscopists. Nitrous oxide was available to 73% of respondents but with considerable regional variation. Most colonoscopists rated the properties of nitrous oxide favourably and would use it if they had a colonoscopy themselves. Despite this, nearly half used it in less than 20% of examinations. 80% instruct patients to use nitrous oxide as required, and differences in how it was used in combination with intravenous sedation and analgesia were reported. Written responses suggest nitrous oxide is often used in the patients who are expected to have the least discomfort.

Conclusions Most colonoscopists perceive that nitrous oxide is effective and reduces inconvenience and would use it themselves if they required a colonoscopy. Studies to improve patient selection and optimise the use of nitrous oxide would be of value.

INTRODUCTION

Nitrous oxide has sedative and analgesic effects. It has a rapid onset and offset of action, which makes it suitable for the management of short episodes of pain. The precise mechanism by which nitrous

oxide exerts its effects is uncertain, but these can be partially reversed by naloxone,¹ suggesting that some of its effects are mediated via the opiate receptor.

Entonox is a 50:50 combination of nitrous oxide and oxygen that is inhaled using a demand valve. Self-administration has associated advantages as it may give patients a feeling of control over their discomfort and may also act as a distraction.

Its role in obstetric and dental practice is long established, but its introduction into colonoscopy practice has occurred relatively recently. Randomised studies describing the use of Entonox during colonoscopy were first published 20 years ago.² Entonox has shown to be safe, well tolerated and reduces time to discharge compared with intravenous sedatives.³ However, occasional patients find it difficult to activate the demand valve.

Most patients are able to use Entonox. It is contraindicated in patients with trapped air since nitrous oxide rapidly diffuses into air spaces: including patients with a pneumothorax, severe bullous emphysema or following a recent dive.⁴

Uptake into UK practice has been slow, and a recent audit reported it was used in only 8.4% of colonoscopies.⁵ We have therefore surveyed the availability, usage and perceptions towards Entonox to gain a better insight into its poor uptake.

MATERIALS AND METHODS

A web-based survey assessing the availability, current practices and perceptions towards Entonox was developed. The survey was modified after an initial pilot of 11 independent colonoscopists and then administered to Bowel Cancer Screening Programme (BCSP) colonoscopists using

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SurveyMonkey, a web-based programme. The study was approved by the English BCSP Research Committee.

Colonoscopists within the English BCSP were initially sent a personalised prenotification email explaining the purpose of the study. A week later they were sent a further email with a web link to the survey followed by a final reminder 2 weeks later.

Respondents were asked their role, endoscopic experience, the National Health Service (NHS) deanery in which they worked and whether Entonox was available in their endoscopy unit. Further questions were then asked according to the availability of Entonox within their unit (boxes 1 and 2). Individuals were able to select from one or more predefined answers and offer written responses. At the end of the survey, there was an opportunity to make further comments.

Comparisons of categorical data were performed using the two-tailed χ^2 test. A *p* value <0.05 was regarded as significant. Thematic analysis was used to assess written responses.⁶ Representative quotations are shown to demonstrate the themes.

Box 1 Questions asked of colonoscopists for whom Entonox was available

Please estimate what proportion of your patients use Entonox?

1) 0–19% 2) 20–39% 3) 40–59% 4) 60–79% 5) 80–100%

Which of the following best describes how Entonox is most often used in your practice?

It is used when patients are in pain despite intravenous sedation and analgesia

Entonox is available from the start of colonoscopy and would be augmented by intravenous sedation/analgesia where required

Other (please state)

How are your patients usually instructed to use Entonox?

Continuously

As required

Other (please state)

Please indicate the extent to which you agree with the following statements:

Entonox is useful during colonoscopy

Entonox gives effective analgesia during colonoscopy

Entonox is a safe option during colonoscopy

Entonox has an acceptable frequency of side effects

Patients who use Entonox leave the endoscopy unit sooner

Would you use Entonox if you were to have a colonoscopy?

Yes

No

Box 2 Questions asked of colonoscopists for whom Entonox was not available

Why is Entonox not available in your unit?

1. Practical difficulties introducing Entonox
2. Satisfaction with current analgesics and sedation
3. Cost
4. Entonox has not been considered
5. Lack of efficacy
6. Side effects
7. Other (please state)

Would you consider introducing Entonox in your unit?

Yes

No

RESULTS

293/298 (98%) BCSP colonoscopists were contacted via email. The survey was accessed by 208 (70%) and completed by 204 (68%).

The respondents comprised 154 physicians, 39 surgeons and 15 nurse endoscopists. Their length of independent practice varied: 0–5 years (2.9%), 6–10 years (18.8%), 11–15 years (39.4%), 16–20 years (23.6%) and 21+ years (15.4%). All English NHS deaneries were represented.

Entonox was available to 152/204 (74.5%), but with considerable variation between deaneries (figure 1). 47.3% of respondents used Entonox during 0–19% of procedures while 32% used it in 20–39%, 12.7% in 40–59%, 7.3% in 60–79% and 0.6% in 80–100% of examinations. Two did not respond, and three indicated that despite Entonox being available, they had not personally used it.

Of those that used Entonox, 87/152 (57.2%) used it mostly from the start of colonoscopy, with intravenous medications being added if necessary, whereas 24/152 (15.8%) mainly used Entonox as an adjunct following earlier administration of sedation. Fifty-two respondents offered further detail describing the use of Entonox. Several stated they used Entonox in both ways depending on the needs of the patient. Some used Entonox in patients wishing to avoid sedation. 18/52 (35%) never combined Entonox with sedation, often according to an endoscopy unit policy, whereas others administered sedatives to patients who had received Entonox did so only after a 5–10 min ‘washout period’. There appeared to be conflict within some units regarding the combination of Entonox and intravenous sedation, for example, ‘Unfortunately the endoscopy staff have a wrong idea that sedated patients should not be given Entonox. It will take time to change the culture’.

Several respondents restricted the use of Entonox to particular procedures or patient groups. Some predominantly use Entonox in screening patients in the belief that individuals are better prepared due to the

Figure 1 Availability of Entonox according to deanery of respondent.

increased nurse input. Others are deterred from using Entonox in females, patients with high anxiety and previous abdominal surgery as 'IV sedation often gives a better experience'.

121/152 (79.6%) respondents stated that Entonox was most often offered to the patient 'when in discomfort or pain' while 11/152 (7.2%) used it 'continuously'. 20/152 (13.2%) did not select a predefined response. 27/152 (17.8%) offered further details, for example, 'dependent on the patient and their needs'. Some suggested that patients 'start with it continually and taper the use depending on comfort and their response to Entonox' while others prompted patients to use it prior to anticipated peak of pain.

Most respondents rated the usefulness, efficacy, safety, influence on time to discharge and acceptability of Entonox favourably (table 1). Respondents who administered Entonox in more than 20% of procedures were more likely to completely or strongly agree with the statements relating to the usefulness (95% vs 69%, OR=8.4, 95% CI 2.4 to 25.9, $p<0.0001$) and effectiveness (76% vs 49%, OR=3.3, 95% CI 1.6 to

6.5, $p=0.001$) of Entonox. However, there was no significant difference between these groups in its perceived safety (97% vs 90%, OR=4.2, 95% CI 0.8 to 21.0, $p=0.085$), frequency of side effects (96% vs 92%, OR=2.3, 95% CI 0.6 to 5.6, $p=0.31$) or effect on time to discharge (79.5% vs 70.4%, OR=1.63, 95% CI 0.8 to 3.4, $p=0.26$).

112/152 (73.7%) indicated that they would use Entonox if they had a colonoscopy themselves. Two did not offer a response. Respondents who used Entonox in more than 20% of procedures were more likely to state that they would use Entonox if they had a colonoscopy (83.5% vs 63.4%, OR=2.9, 95% CI 1.4 to 6.3, $p=0.006$).

Of the 52 respondents for whom Entonox was not available, 38.4% indicated that this was due to 'practical difficulties introducing Entonox', 28.8% due to 'satisfaction with current analgesics and sedation', 13.4% due to 'cost', 11.5% as 'Entonox has not been considered', 3.8% due to 'lack of efficacy' and 1.9% due to 'side effects'. Twenty respondents also offered a written response with over half of these stating that Entonox was in the process of being introduced in their unit. The rollout of Bowel Scope was cited as a stimulus for its introduction. Entonox had been withdrawn from the endoscopy unit of two respondents due to concerns regarding inadequate ventilation.

Patient choice was a common theme of the text responses. Respondents suggested that patients choose Entonox when they anticipate having little discomfort and wish to avoid the restrictions associated with intravenous medication—'particularly those who live alone or wish to drive'.

There were conflicting comments regarding the efficacy of Entonox. Some stated it was 'useless', 'unpredictable' and 'not as good as trials suggest' while others felt it was 'very useful', 'very effective' and 'Entonox is my preference'. Furthermore, some felt that 'it is underused and needs more promotion within the unit' and others had concerns that 'Entonox is being promoted by nurses who see quick recovery times at the end of a list as an advantage'.

Respondents identified difficulties for the patient and endoscopist associated with the inhalation of Entonox, with comments such as 'some patients struggle to inhale Entonox effectively' and 'Entonox can

Table 1 Agreement of respondents with statements about Entonox n (%)

	Do not agree	Slightly agree	Somewhat agree	Mostly agree	Completely agree
'Entonox is useful during colonoscopy'	2 (1.3%)	10 (6.6%)	14 (9.3%)	58 (38.4%)	67 (44.4%)
'Entonox gives effective analgesia during colonoscopy'	2 (1.3%)	13 (8.6%)	41 (27.2%)	62 (41.1%)	33 (21.9%)
'Entonox is a safe option during colonoscopy'	0 (0%)	2 (1.3%)	7 (4.6%)	49 (32.5%)	93 (61.6%)
'Entonox has an acceptable frequency of side effects'	2 (1.3%)	3 (2.0%)	4 (2.7%)	52 (34.7%)	89 (59.3%)
'Patients who use only Entonox leave the endoscopy unit sooner'	13 (8.7%)	1 (0.7%)	23 (15.3%)	43 (28.7%)	70 (46.7%)

rarely make the procedure itself more difficult as the deep breathing impairs the colonoscopists ability to negotiate bends with fine movements’.

DISCUSSION

Many patients find colonoscopy an unpleasant procedure, and a range of medications is available to improve patients’ experience. The processes and determinants of drug use during colonoscopy are not well studied but are likely to include patient choice, endoscopist choice, endoscopy unit policy and patient experience during colonoscopy. The attitudes and priorities of patients towards sedation vary. For some, the priority is being pain free or unaware, whereas others want a rapid recovery and discharge or to remain in control and view the examination.⁷ The use of medication should therefore be tailored to meet the needs of the individual.

Entonox has been advocated for use during colonoscopy as it has a quick onset of action, rapid clearance and combined analgesic and sedative properties. This makes it well suited for the management of brief painful episodes, particularly for patients wishing to avoid the inconvenience associated with intravenous sedatives. Despite its favourable characteristics, Entonox is used in only a small proportion of colonoscopy examinations in the UK. We sought to understand the reasons for its low use.

In the present study, Entonox was available to three-quarters of respondents. Most of these perceived it to have favourable characteristics, and three-quarters would use it if they had a colonoscopy themselves. Despite this, nearly half used it in less than 20% of their examinations. The positive perceptions of Entonox within colonoscopists are at odds with its low usage in clinical practice. The reasons for this are unclear. Potential determinants of Entonox use may include patient choice, endoscopy unit policy and the preferences of the colonoscopist. The wide variation in Entonox use suggests the relative contribution of these factors varies between units.

Patient choice was often cited as a factor that influenced the use of Entonox. It was often used in patients wishing to avoid the inconvenience associated with sedation use. Patients receiving intravenous sedatives and opiates are generally told to avoid driving for 24 h and to be with a responsible adult for the same period, whereas patients receiving Entonox only have to refrain from driving for 30 min. This reduced inconvenience makes Entonox an attractive option for many patients. Several respondents had not introduced Entonox into their unit as they were satisfied with their current analgesics.

Many respondents preferred to use intravenous medications rather than Entonox in the patients expected to have most discomfort. This is in keeping with the BSG guidelines that suggest Entonox may be best used during moderately painful procedures.⁸

Although this statement implies that intravenous medications are more efficacious than Entonox, a recent Cochrane review reported there were no clear differences between Entonox and intravenous sedatives with regards to pain relief, but highlighted the need for further high-quality studies.³ However, the potency of Entonox remains poorly defined,⁹ and further studies are clearly indicated.

Most respondents instruct patients to use Entonox as required. Published studies have employed varied methods of administration. Some recommend continual use until the caecum is reached^{10 11} or until the sigmoid colon has been traversed.¹² Others recommend its use as required, either with or without preloading prior to intubation.^{13 14} There are no comparative studies of different methods of administration in endoscopic practice, although Westling *et al* found continuous use to be more effective than as required use during vaginal delivery.¹⁵

The present study found marked variation between colonoscopists in how and whether Entonox is combined with intravenous sedation and/or opiate analgesia. Previous studies examining nitrous oxide use during colonoscopy vary as to whether it was combined with intravenous medications and whether it was used concurrently,^{2 12} or after a washout period.^{10 11} Dental studies report the combination to be safe and reduce the requirement for midazolam, shorten recovery times and improve patient cooperation.¹⁶ Clinical studies to clarify the safety and efficacy of Entonox as an adjunct to intravenous medication during colonoscopy would be of clinical value.

Prolonged Entonox exposure can result in serious neurological and haematological side effects,¹⁷ and there have been concerns about effects on fertility.¹⁸ The UK Health and Safety Executive state the level of occupational exposure should not exceed 100 ppm¹⁹ (time weighted average over 8 h), but standards differ between countries. The Entonox Summary of Product Characteristics suggests it should be administered in rooms with ‘ventilation and/or exchange systems set to the proper level’. Direct measurement of nitrous oxide concentration is possible, but it is more common to assess its safety by measuring adequacy of ventilation. This can be assessed by measuring air changes per hour (ac/h). The minimum ac/h necessary to maintain a concentration of nitrous oxide below 100 ppm is not defined as it is dependent on the amount used. Some UK hospital guidelines suggest Entonox can be safely administered in rooms having 5–6 ac/h. This is considerably less than 15 ac/h, which is recommended by the UK Department of Health guidelines,²⁰ for all endoscopy rooms, regardless of Entonox use. Individual units must make an appropriate assessment of risk.

A limitation of the current study is that only the views of BCSP colonoscopists were surveyed. Despite this, we feel the results can be generalised since

practices within endoscopy units are likely to be similar. Furthermore, sampling this group also had advantages as it provided a cross section of physicians, surgeons and nurse endoscopists from all regions and resulted in a high response rate. It is also unclear from the present study what proportion of patients are offered Entonox and how this selection process occurs. This is worthy of further study.

Several techniques were employed in the design and administration of this survey to maximise response rate.²¹ Invitations were personalised, a prenotification and reminder email were sent, the survey was short, a deadline for completion was set, we believed the topic was of interest to the potential respondents and a summary of the results was offered.

A number of uncertainties remain regarding the use of Entonox, and this may, in part, explain its low uptake to date. It is uncertain whether Entonox is best used in particular patient groups. Furthermore, the optimal method of administration is uncertain. And finally, the safety and efficacy of Entonox as an adjunct to intravenous sedatives and analgesics during colonoscopy is also an area worthy of further study.

CONCLUSIONS

Although most BCSP endoscopists rate the properties of Entonox favourably, its use remains highly selective. The use and availability of Entonox is likely to increase in the UK due to the rollout of Bowel Scope. Optimising the use of Entonox and identifying the patients for whom it is of most benefit will help further define its role in colonoscopy.

What is already known on this topic

- ▶ Entonox has both sedative and analgesic properties.
- ▶ Entonox is rapidly eliminated such that patients may drive half an hour after use.
- ▶ Entonox is used during a minority of colonoscopy examinations in the UK.

What this study adds

- ▶ Entonox is widely available but there are regional variations.
- ▶ The method of Entonox administration is variable but most instruct patients to use it as required.
- ▶ There is considerable variation in how Entonox is combined with sedation and analgesia.
- ▶ Most colonoscopists had positive perceptions of Entonox and three-quarters would use it if they required colonoscopy themselves.

How might it impact on clinical practice in the foreseeable future

- ▶ Readers may reflect on their own practices and consider Entonox use more frequently.
- ▶ This study may stimulate further research to optimise the method of Entonox administration and improve patient selection.

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