Does Supplemental Oxygen Reduce Postoperative Nausea and Vomiting? A Meta-Analysis of Randomized Controlled Trials

Mukadder Orhan-Sungur, MD*†

Peter Kranke, MD, MBA, PhD‡

Daniel Sessler, MD§

Christian C. Apfel, MD, PhD*‖

BACKGROUND: Studies on the ability of supplemental oxygen to decrease the incidence of postoperative nausea and vomiting (PONV) are inconsistent, with initial studies suggesting benefit while subsequent trials demonstrate no decrease in PONV.

METHODS: To clarify whether supplemental oxygen is an effective and reliable method to reduce PONV, we performed a systematic review (MEDLINE, Cochrane Library, hand searching and bibliographies, with no language restriction, through March 2006) of randomized, controlled trials comparing perioperative 80% versus 30%–40% F_{IO_2} on the incidence of PONV. For this systematic review, PONV was defined as any nausea, retching, and/or vomiting in the first 24 h after surgery. The end-points were early PONV (0–6 h), late PONV (6–24 h), and overall PONV (0–24 h). Data from 10 trials with 1729 patients were included in our meta-analysis: 860 received 80% F_{IO_2} and 869 received 30%–40% F_{IO_2}.

RESULTS: In patients who received 80% F_{IO_2},the relative risk (95% confidence intervals) of experiencing early PONV was 0.91 [0.71–1.16]; late PONV, 0.88 [0.69–1.11]; and overall PONV, 0.91 [0.77–1.06]. Results were similar for early, late, and overall nausea and vomiting.

CONCLUSIONS: The positive results of two initial studies reducing the risk for PONV in patients given 80% F_{IO_2} were not confirmed by any of the subsequent trials. Considering all available evidence, 80% F_{IO_2} should no longer be considered an effective or reliable method to reduce overall PONV.

(Anesth Analg 2008;106:1733–8)

Studies on the use of supplemental oxygen to decrease the incidence of postoperative nausea and vomiting (PONV) have yielded controversial results, resulting in confusion among clinicians whether to use supplemental oxygen as a strategy to reduce the risk for PONV. We therefore performed a systematic review to collect and analyze the best available evidence on the effectiveness of this intervention.

The idea that supplemental oxygen may have antiemetic properties originated from studies investigating the decreased emetogenic effect of nitrous oxide in patients receiving high concentrations of oxygen instead of air. Overdyk and Roy were first to question whether the reduction in PONV in such studies was the result of high concentrations of supplemental oxygen rather than the absence of nitrous oxide.[1]

Two years later, Greif et al.[2] reported in a randomized, controlled study that supplemental oxygen reduces the incidence of PONV; however, this trial was not designed to demonstrate a reduction in PONV but rather in wound healing. Subsequently, the same group found that supplemental oxygen was at least as effective in reducing PONV after gynecological laparoscopy as it was after colon surgery, leading Goll et al. to postulate that supplemental oxygen might decrease subtle intestinal ischemia under anesthesia and, consequently, decrease the incidence of PONV.[3] Subsequent trials comparing supplemental oxygen with standard oxygen in nitrogen have not confirmed these promising initial results.[4–8] To resolve this controversy, we performed a systematic review to determine whether supplemental intraoperative oxygen is a promising clinical strategy to reduce PONV.

METHODS

We performed a systematic search for randomized, controlled trials that tested the hypothesis that prophylactic supplementation of air with high (80%)

From the *Outcomes Research Institute, and †Department of Anesthesiology and Perioperative Medicine, University of Louisville, Louisville, Kentucky; ‡Department of Anesthesiology, University of Wuerzburg, Wuerzburg, Germany; §Department of Outcomes Research, Cleveland Clinic Foundation; ‖Perioperative Clinical Research Core, Department of Anesthesiology and Perioperative Care, University of California, San Francisco, California.

Accepted for publication February 22, 2008.

Supported by NIH Grant GM 061655 (Bethesda, MD), the Gheens Foundation (Louisville, KY), the Joseph Drown Foundation (Los Angeles, CA), and the Commonwealth of Kentucky Research Challenge Trust Fund (Louisville, KY).

Address correspondence and reprint requests to Christian C. Apfel, MD, PhD, Perioperative Clinical Research Core, Department of Anesthesiology and Perioperative Care, University of California at San Francisco (UCSF), 1600 Divisadero St., San Francisco, CA. Address e-mail to apfel@ponv.org or web: www.ponv.org.

DOI: 10.1213/ane.0b013e3181731c5a

versus low (30%–40%) oxygen concentration during general anesthesia decreases PONV. Patients who received 80% oxygen in air are referred to as the "supplemental oxygen" group and patients who received 30%–40% oxygen are referred to as the "air" group.

The main outcomes were emetic events reported in a dichotomous form (i.e., presence or absence of nausea, vomiting, and/or retching with either supplemental oxygen or air). We searched MEDLINE (from 1996), Science Citation Index, and Cochrane Library (Issue 4, 2004) databases without any language restriction using the following free text and associated MeSH terms: [oxygen AND (nausea OR vomiting)] OR (supplemental oxygen AND anesthesia). References within all identified studies were hand-searched until no new references were found. The last electronic search was performed in July 2005 and updated in March 2006.

Three authors (C.C.A., M.O.S., and P.K.) independently read all reports and abstracts that could possibly meet the inclusion criteria and scored them based on the reported methodology, including adequacy of randomization and allocation concealment, blinding of the study, and description of withdrawals (Jadad Scale).[9] The reports were also assigned a nonnumerical assessment based on the Cochrane Reviewers' Handbook.

Data on type of surgery, risk factors, interventions, and outcomes in each trial were extracted using a prespecified format in an Excel worksheet. We distinguished between abdominal and nonabdominal surgery because differences in outcome might depend on underlying pathophysiological mechanisms.

Incidence of PONV was extracted and evaluated for three time periods: the early period was defined as the earliest reported interval within 0–6 h after surgery, the late period was defined as 6–24 h after surgery, and the overall period was defined as 0–24 h after surgery. When incidence of events was reported for different early intervals, we chose the earliest interval (e.g., 0–2 h instead of 0–6 h) to increase the chance of detecting different effects in the early versus the late periods.

Nausea was defined as an unpleasant sensation with awareness of the urge to vomit. Emesis was defined as successful or unsuccessful expulsion of gastric contents (vomiting or retching). PONV was defined as any nausea, retching, and/or vomiting. All events (nausea, emesis, and PONV) were extracted in dichotomous form. These events were analyzed separately.

For sensitivity analyses, we further explored the data for robustness of the obtained results by separating the included trials according to type of surgery (abdominal and nonabdominal surgery), and we also reevaluated the subsequent trials excluding the first two original trials,[2,3] given that these results have not been reproduced by others.

A random effects model was used for the calculation of relative risks (RRs) with supplemental oxygen versus air and the associated 95% confidence intervals (CI) (Review Manager 4.2, Cochrane Collaboration, Oxford, UK). When the 95% CI around the RR did not include the number one, we assumed a statistically significant difference between supplemental oxygen and standard oxygen in nitrogen (air).

RESULTS

Our electronic search revealed five studies that met our inclusion criteria.[2–6] A hand search of anesthesia meeting abstracts and personal communications revealed an additional study from our own group,[7,8] two then unpublished studies,[10,11] and one abstract.[12] For the two unpublished studies, the primary investigators responded to our inquiries and provided data after the articles were accepted for publication.[10,11] One study was initially published as an abstract but has since been published as a full paper.[12] A further published trial was found on secondary electronic search and contained three groups in which the patients were randomized to 30, 50, or 80% oxygen in nitrogen.[13] We included the 30% and 80% oxygen groups in this meta-analysis. A final included study was found in the dental literature.[14] One study was excluded because we considered the comparison of 50% versus 30% oxygen too small a difference to reveal an antiemetic effect.[4] Thus, 1729 patients from 10 studies are considered in this meta-analysis (Table 1).

The RR for PONV within the first 24 h after surgery in the patients receiving 80% oxygen as opposed to 30%–40% oxygen was 0.91 [95% CI 0.77–1.06] (Fig. 1). This finding did not change appreciably when abdominal and nonabdominal surgical patients were analyzed separately; RRs were 0.81 (0.56–1.18) and 0.97 (0.83–1.12), respectively. Two initial studies that were conducted in Vienna, Austria, had positive results (RRs of 0.56 and 0.49); in contrast, all other studies were negative, which led to heterogeneity among the studies ($P = 0.01$ in patients undergoing abdominal surgery and $P = 0.10$ in all patients). The RRs for early, late, and overall vomiting were 0.72, 0.88, and 0.82, respectively (Table 2), none of which were statistically significant. In the abdominal surgery subgroup, supplemental oxygen was associated with significantly decreased vomiting; however, when the two initial positive studies[2,3] were excluded from the analysis, none of the comparisons remained statistically significant. Values for nausea were similar to those of PONV (Table 2). The RRs for nausea did not change when the abdominal and nonabdominal groups were analyzed separately; the RRs for overall nausea were 0.79 [0.54–1.16] and 0.95 [0.81–1.12], respectively.

Table 1. Randomized Controlled Trials Included in the Meta-Analysis on the Influence of Supplemental Oxygen on Postoperative Nausea and Vomiting

Reference	Jadad scale[a]	Procedure	Oxygen concentration (*n*)		Excluded intervention groups	Outcomes used in meta-analysis	Comment
Greif et al., 1999[2]	2/2/0	Colon surgery	80% (112)	30% (119)	None	Early (0–6 h), late (6–24 h) and overall (0–24 h) PON, POV, PONV	Oxygen was continued 2 h after surgery according to the assigned F_{IO_2}
Goll et al., 2001[3]	2/2/0	Gynecologic laparoscopy	80% (79)	30% (80)	Oxygen 30% + Ondansetron 8 mg (n = 81)	Early (0–6 h), late (6–24 h) and overall (0–24 h) PON, POV, PONV	Patients received 2 L/min oxygen for 2 h postoperatively
Purhonen et al., 2003[5]	2/2/1	Gynecologic laparoscopy	80% (49)	30% (50)	None	Early (until end of PACU stay), late (end of PACU stay until discharge) and overall (0–24 h) PON, POV, PONV	Oxygen was continued 1 h after surgery according to assigned F_{IO_2}
Joris et al., 2003[6]	1/2/0	Thyroid surgery	80% (50)	30% (50)	Oxygen 30% + Droperidol 0.625 mg (n = 50)	Early (0–2 h) and overall (0–24 h) PON, POV, PONV Late (6–24 h) PON, POV	Oxygen was continued 2 h after surgery according to assigned F_{IO_2} First author provided PONV data for early and overall period
Turan et al., 2006[8]	2/2/1	Abdominal and nonabdominal surgery	80% (280)	30% (279)	Based on a study with factorial design	Early (0–2 h), late (6–24 h) and overall (0–24 h) PON, POV, PONV	Patients at high risk for PONV according to a simplified risk score were included in the study
Piper et al., 2006[12b]	1/1/0	Laparoscopic cholecystectomy	80% (125)	40% (125)	60 % N_2O (n = 127)	Early (0–2 h) POV, PONV Overall (0–24 h) POV, PONV	All patients received 2 L/min oxygen via nasal cannula while in PACU
Treschan et al., 2005[11]	2/2/1	Strabismus surgery	80% (68)	30% (71)	Oxygen 30% + Ondansetron 75 μg/kg (n = 71)	Early (0–6 h) and overall (0–24 h) PON, POV, PONV Late (6–24 h) PONV	Pediatric and adult strabismus surgery patients
Purhonen et al., 2006[10]	2/2/1	Breast surgery	80% (29)	30% (28)	Oxygen 30% + Ondansetron 4 mg (n = 28)	Early (0–2 h) and overall (0–24 h) PON, POV, PONV Late (6–24 h) PONV	Oxygen was continued 2 h after surgery according to assigned F_{IO_2}
Bhatnagar et al., 2005[13]	2/1/0	Modified mastectomy	80% (20)	30% (20)	Oxygen 50% in nitrogen	Early (0–2 h) and late (6–24 h) PONV Overall (0–24 h) PON, PONV	Oxygen supplemented postoperatively if saturation was less than 95%
Donaldson et al., 2005[14]	2/2/1	Dental surgery	80% (48)	30% (47)	None	Early (until end of PACU stay) PON, POV, PONV Late (end of PACU to day procedure discharge) PON Overall (0 to discharge) PONV	Pediatric Dental surgery patients

PON = postoperative nausea; POV = postoperative vomiting; PONV = postoperative nausea and vomiting; PACU = postanesthesia care unit.

[a] Randomization/blinding/follow-up.

[b] Abstract presented at the Meeting of the German Society of Anesthesiologists, 2004, Munich, Germany (FV 1–9.1).

DISCUSSION

Two initial studies, co-authored by one of our authors (D.I.S.), postulated that oxygen might be effective at reducing PONV via prevention of subtle intestinal ischemia and hypoxia associated with abdominal surgery.[2,3] Proposed mechanisms included surgical stress[15] or increased intraabdominal pressure,[16] both of which reduce intestinal blood flow. Decreased blood flow is potentially important since subtle ischemia of the intestine might trigger serotonin release, which causes nausea and vomiting in at least some (nonanesthetic) circumstances.[17] However, later studies involving abdominal surgeries were negative for an increased risk of PONV.[5,7,8,12]

Considering the heterogeneity among the groups, we tested the hypothesis that the type of surgery might determine the efficacy of supplemental oxygen on PONV. Therefore, we performed a sensitivity analysis of the results based on the type of surgery (abdominal and nonabdominal surgeries). Our results suggest that increased intraoperative supplemental oxygen has no effect on overall PONV, regardless of type of surgery.

The half-life of serotonin is only a few minutes and, as a result, data correlating postoperative levels and PONV are lacking. One study found higher plasma concentrations of serotonin metabolites (5-hydroxyindolic acid) after abdominal surgery to be associated with a higher

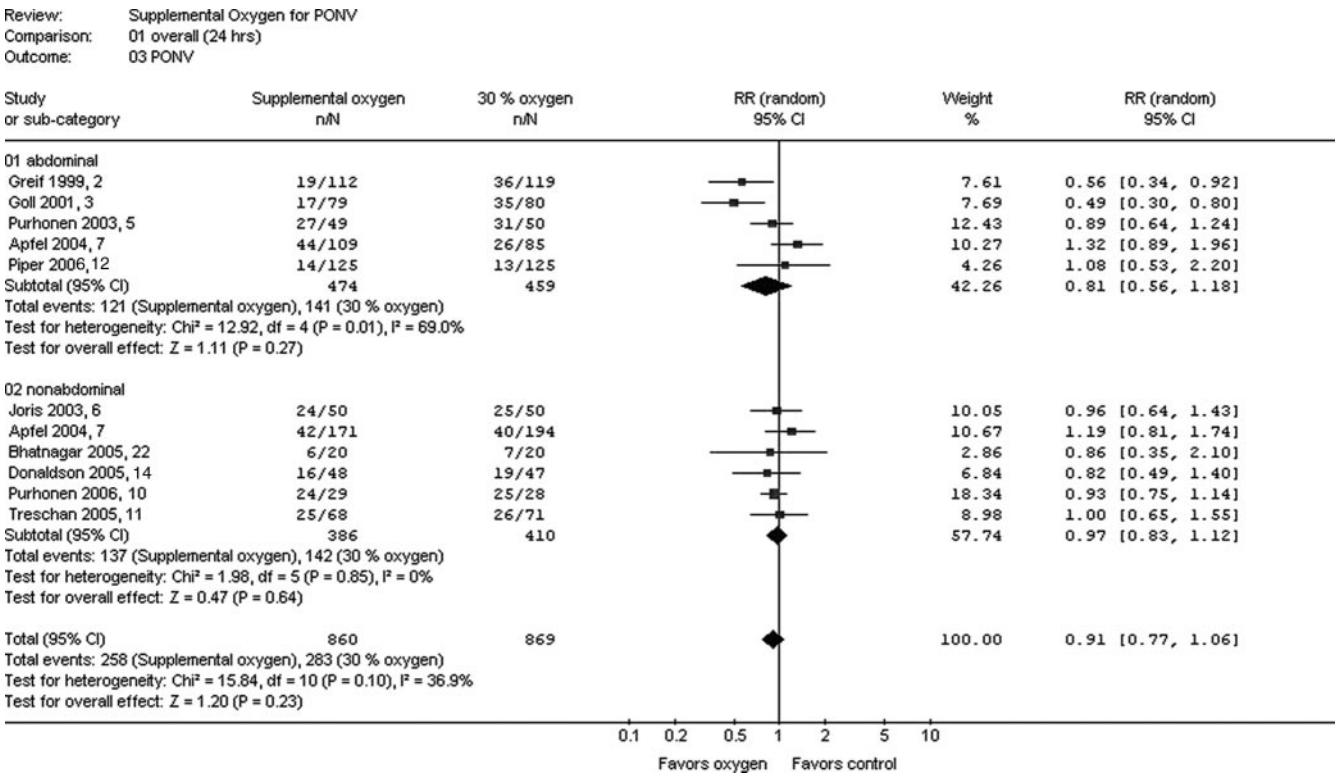

Figure 1. Comparison of patients with and without supplemental oxygen according to abdominal and nonabdominal surgery. The end-point is the presence of postoperative nausea and/or vomiting (PONV) over the entire study period of 24 h. RR = relative risks; CI = confidence intervals.

Table 2. Relative Risks (RR) and 95% Confidence Intervals (CI) for the Compared Trials (RR >1 Favors Air Whereas RR <1 Favors Supplemental Oxygen)

Type of surgery	Time	Outcome	RR in % [95 CI]	Greif[2] and Goll et al.[3] data excluded
Abdominal	Early	Nausea	0.90 [0.50–1.60]	1.49 [0.89–2.50]
		Vomiting	0.42 [0.22–0.82]	0.37 [0.12–1.20]
		PONV	0.90 [0.56–1.43]	1.34 [0.86–2.07]
	Late	Nausea	0.69 [0.39–1.25]	0.93 [0.43–1.98]
		Vomiting	0.69 [0.38–1.24]	0.90 [0.45–1.82]
		PONV	0.72 [0.41–1.29]	1.03 [0.58–1.85]
	Overall	Nausea	0.79 [0.54–1.16]	1.04 [0.69–1.57]
		Vomiting	0.62 [0.40–0.97]	0.83 [0.51–1.34]
		PONV	0.81 [0.56–1.18]	1.06 [0.81–1.39]
Nonabdominal	Early	Nausea	0.96 [0.72–1.28]	Not applicable
		Vomiting	1.29 [0.57–2.92]	Not applicable
		PONV	0.94 [0.71–1.24]	Not applicable
	Late	Nausea	1.01 [0.80–1.27]	Not applicable
		Vomiting	0.94 [0.70–1.25]	Not applicable
		PONV	0.94 [0.76–1.16]	Not applicable
	Overall	Nausea	0.95 [0.81–1.12]	Not applicable
		Vomiting	0.96 [0.73–1.27]	Not applicable
		PONV	0.97 [0.83–1.12]	Not applicable
All types of surgery	Early	Nausea	0.91 [0.70–1.18]	1.07 [0.83–1.38]
		Vomiting	0.72 [0.45–1.17]	0.88 [0.48–1.59]
		PONV	0.91 [0.71–1.16]	1.04 [0.82–1.31]
	Late	Nausea	0.88 [0.68–1.13]	1.00 [0.81–1.22]
		Vomiting	0.88 [0.68–1.13]	0.93 [0.72–1.21]
		PONV	0.88 [0.69–1.11]	0.97 [0.81–1.17]
	Overall	Nausea	0.89 [0.74–1.06]	0.97 [0.84–1.11]
		Vomiting	0.82 [0.64–1.05]	0.93 [0.73–1.18]
		PONV	0.91 [0.77–1.06]	0.99 [0.87–1.12]

PONV = postoperative nausea and vomiting.

incidence of PONV[18]; however, these results have not been reproduced. Moreover, one would expect the emetogenic effects of serotonin to correspond with peak levels of serotonin, i.e., intraoperatively, rather than with the inactive metabolites postoperatively. In accordance with previous studies,[19,20] Apfel et al.[7] found that ondansetron, a serotonin receptor antagonist, is no more effective than droperidol or dexamethasone in that all reduce the incidence of PONV by approximately 30%, and there is no indication that serotonin-antagonists are more effective for abdominal versus other types of surgery. Additionally, the RR reduction for each of these three antiemetics was independent of the type of surgery, be it abdominal or otherwise. Also of note, the classic "carcinoid triad" associated with a serotonin-secreting tumor includes flushing, diarrhea, and cardiac involvement, but not nausea or vomiting.[21] Thus, serotonin release is unlikely to play a major role in PONV, even after abdominal surgery.

It has been suggested that oxygen administration and subsequent high arterial oxygen tension may have a central antinausea effect as a result of decreased dopamine release in the carotid bodies. In support of this theory, Kober et al.[22] reported that supplemental oxygen administration was effective in preventing motion sickness of geriatric patients during prehospital transport, presumably by decreased carotid body stimulation and subsequent dopamine-dependent stimulation of the chemoreceptor trigger zone. However, this finding was not confirmed by Ziavra et al.,[23] who could not show a beneficial antinausea effect of supplemental oxygen versus air in a provocative motion trial to mimic motion sickness in volunteers.

Finally, if high oxygen concentration has some intrinsic (perhaps central) antiemetic effect, one would expect this would be most detectable while the high concentration of oxygen is administered. But a study from Goll et al.[3] in which supplemental oxygen was restricted to the intraoperative period was positive, whereas studies from Purhonen et al.[5] and Joris et al.[6] were negative, even though supplemental oxygen was given in these latter studies for an additional 1–2 h after surgery. Furthermore, a study by Ghods et al.[24] confined oxygen administration to the postoperative period alone, and concluded that postoperative oxygen supplementation of 50% did not prevent PONV in patients undergoing cesarean delivery.

In conclusion, although meta-analyses have innate limitations,[25] the results of our systematic review provide evidence that the use of supplemental oxygen does not lead to an overall reduction in PONV. Supplemental oxygen can thus no longer be recommended as an effective strategy to prevent PONV.

ACKNOWLEDGMENTS

We thank Prof. Dr. Leopold Eberhart (Germany) for sharing his initial analyses for cross-reference; and Priv.-Doz. Dr. Sven Piper and colleagues (Ludwigshafen, Germany) for providing data from their study even before submitting an original manuscript, all of which were essential for the completeness of this meta-analysis. We also thank Nancy Alsip, PhD, Roxanne Rapan, MD, MPH, and Anuj Malhotra, MD, for editing the manuscript.

REFERENCES

1. Overdyk FJ, Roy RC. If nitrous oxide induces emesis, maybe 100% oxygen is an antiemetic. Anesth Analg 1997;84:231–2
2. Greif R, Lacyni S, Rapf B, Hickle RS, Sessler DI. Supplemental oxygen reduces the incidence of postoperative nausea and vomiting. Anesthesiology 1999;91:1246–52
3. Goll V, Akca O, Greif R, Freitag H, Arkilic CF, Scheck T, Zoeggeler A, Kurz A, Krieger G, Lenhardt R, Sessler DI. Ondansetron is no more effective than supplemental intraoperative oxygen for prevention of postoperative nausea and vomiting. Anesth Analg 2001;92:112–7
4. Purhonen S, Niskanen M, Wustefeld M, Mustonen P, Hynynen M. Supplemental oxygen for prevention of nausea and vomiting after breast surgery. Br J Anaesth 2003;91:284–7
5. Purhonen S, Turunen M, Ruohoaho U-M, Niskanen M, Hynynen M. Supplemental oxygen does not reduce the incidence of postoperative nausea and vomiting after ambulatory gynecologic laparoscopy. Anesth Analg 2003;96:91–6
6. Joris JL, Poth NJ, Djamadar AM, Sessler DI, Hamoir EE, Defechereux TR, Meurisse MR, Lamy ML. Supplemental oxygen does not reduce postoperative nausea and vomiting after thyroidectomy. Br J Anaesth 2003;91:857–61
7. Apfel CC, Korttila K, Abdalla M, Kerger H, Turan A, Vedder I, Zernak C, Danner K, Jokela R, Pocock SJ, Trenkler S, Kredel M, Biedler A, Sessler DI, Roewer N. A factorial trial of six interventions for the prevention of postoperative nausea and vomiting. N Engl J Med 2004;350:2441–51
8. Turan A, Apfel CC, Kumpch M, Danzeisen O, Eberhart LH, Forst H, Heringhaus C, Isselhorst C, Trenkler S, Trick M, Vedder I, Kerger H. Does the efficacy of supplemental oxygen for the prevention of postoperative nausea and vomiting depend on the measured outcome, observational period or site of surgery? Anaesthesia 2006;61:628–33
9. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, McQuay HJ. Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials 1996;17:1–12
10. Purhonen S, Niskanen M, Wustefeld M, Hirvonen E, Hynynen M. Supplemental 80% oxygen does not attenuate post-operative nausea and vomiting after breast surgery. Acta Anaesthesiol Scand 2006;50:26–31
11. Treschan TA, Zimmer C, Nass C, Stegen B, Esser J, Peters J. Inspired Oxygen Fraction of 0.8 Does Not Attenuate Postoperative Nausea and Vomiting after Strabismus Surgery. Anesthesiology 2005;103:6–10
12. Piper SN, Rohm KD, Boldt J, Faust KL, Maleck WH, Kranke P, Suttner SW. Inspired oxygen fraction of 0.8 compared with 0.4 does not further reduce postoperative nausea and vomiting in dolasetron-treated patients undergoing laparoscopic cholecystectomy. Br J Anaesth 2006;97:647–53
13. Bhatnagar S, Mishra S, Gupta M, Singhal AK, Mandal AS. Effects of different concentrations of intraoperative supplemental oxygen on post-operative nausea and vomiting (PONV) in patients under going modified radical mastectomy. Internet J Anesthesiol 2005;9
14. Donaldson AB. The effect of supplemental oxygen on postoperative nausea and vomiting in children undergoing dental work. Anaesth Intensive Care 2005;33:744–8
15. Gelman S, Dillard E, Bradley EL Jr. Hepatic circulation during surgical stress and anesthesia with halothane, isoflurane, or fentanyl. Anesth Analg 1987;66:936–43
16. Caldwell CB, Ricotta JJ. Changes in visceral blood flow with elevated intraabdominal pressure. J Surg Res 1987;43:14–20
17. Oktedalen O, Lunde OC, Opstad PK, Aabakken L, Kvernebo K. Changes in the gastrointestinal mucosa after long-distance running. Scand J Gastroenterol 1992;27:270–4
18. Laer S, Scholz J, Ritterbach C, Laer C, Rahme E, Schulte Am Esch J. Association between increased 5-HIAA plasma concentrations and postoperative nausea and vomiting in patients undergoing general anaesthesia for surgery. Eur J Anaesthesiol 2001;18:833–5

19. Fortney JT, Gan TJ, Graczyk S, Wetchler B, Melson T, Khalil S, McKenzie R, Parrillo S, Glass PS, Moote C, Wermeling D, Parasuraman TV, Duncan B, Creed MR. A comparison of the efficacy, safety, and patient satisfaction of ondansetron versus droperidol as antiemetics for elective outpatient surgical procedures. S3A-409 and S3A-410 Study Groups. Anesth Analg 1998;86:731–8
20. Tang J, Chen X, White PF, Wender RH, Ma H, Sloninsky A, Naruse R, Kariger R, Webb T, Zaentz A. Antiemetic prophylaxis for office-based surgery: are the 5-HT3 receptor antagonists beneficial? Anesthesiology 2003;98:293–8
21. McCormick D. Carcinoid tumors and syndrome. Gastroenterol Nurs 2002;25:105–11
22. Kober A, Fleischackl R, Scheck T, Lieba F, Strasser H, Friedmann A, Sessler DI. A randomized controlled trial of oxygen for reducing nausea and vomiting during emergency transport of patients older than 60 years with minor trauma. Mayo Clin Proc 2002;77:35–8
23. Ziavra NV, Yen Pik Sang FD, Golding JF, Bronstein AM, Gresty MA. Effect of breathing supplemental oxygen on motion sickness in healthy adults. Mayo Clin Proc 2003;78:574–8
24. Ghods AA, Soleimani M, Narimani M. Effect of postoperative supplemental oxygen on nausea and vomiting after cesarean birth. J Perianesth Nurs 2005;20:200–5
25. White PF, Watcha MF. Has the use of meta-analysis enhanced our understanding of therapies for postoperative nausea and vomiting? 1999;88:1200–2