CrossMark

ORIGINAL ARTICLE

Predisposing factors for postoperative nausea and vomiting in gynecologic tumor patients

Daiane Spitz de Souza[1] · Amine Farias Costa[2] · Gabriela Villaça Chaves[2,3]

Abstract

Purpose To evaluate the predictors of postoperative nausea and vomiting (PONV) in women with gynecologic tumor.

Methods The analysis was based on prospectively collected data of 82 adult patients with gynecologic tumor, who were submitted to open surgical treatment and undergoing general anesthesia. The predictors included were age ≥50 years, nonsmoker, use of postoperative opioids, mechanical bowel preparation, intraoperative intravenous hydration (IH) ≥10 mL/kg/h, and IH in the immediate postoperative, first and second postoperative days (PO1 and PO2) ≥30 mL/kg. A score with predictor variables was built. A multiple logistic regression was fitted. To estimate the discriminating power of the chosen model, a receiver operating characteristic (ROC) curve was plotted and the area under the ROC curve (AUC) was calculated. Statistical significance was set at p value <0.05 and the confidence interval at 95 %.

Results The incidence (%) of nausea, vomiting and both, in the general population, was 36.6, 28.1, 22.0, respectively. The highest incidences of PONV were found in non-smokers and in patients who received >30 mL/kg of IH in the PO2. The results of the adjusted model showed an increased risk of PONV for each 1-point increase in the score punctuation. The relative risk was higher than 2.0 for vomiting in all period and in the PO1. The ROC curve showed great discrimination of postoperative nausea and vomiting from the proposed score (AUC >0.75).

Conclusions The study population was at high risk of PONV. Therefore, institutional guidelines abolishing modifiable variables following temporal evaluation of the effectiveness should be undertaken.

Keywords Gynecologic tumor · Postoperative nausea and vomiting · Perioperative care

Introduction

Postoperative nausea and vomiting (PONV) is common, unpleasant, and harmful. The estimated incidence is 25–30 % [1] in the general population, reaching 70–80 % in high-risk patients [2, 3]. The genesis of PONV is multifactorial, involving surgical, anesthetic, and patient risk factors [1, 4, 5].

When symptoms are intense, PONV could be associated with anastomotic leakage, bleeding, electrolyte imbalance, dehydration, and aspiration of gastric contents, besides prolonged periods of fasting, resulting in increased costs and length of hospital stay [6].

Gynecologic surgery has been considered an independent risk factor for PONV [7]. The causes for PONV after gynecology surgeries are related to age, obesity, motion sickness, history or previous PONV, and pain in the postoperative period [8, 9].

Antiemetic strategy is one of the elements of multimodal enhanced recovery after surgery (ERAS) program, which consists in several perioperative routines such as pre and postoperative fasting, mechanical bowel preparation (MBP), perioperative anesthesia, analgesia, and intravenous hydration (IH) that, when combined, could influence the recovery in the postoperative period [10].

✉ Gabriela Villaça Chaves
   gabrielavc@gmail.com

1   Department of Nutrition and Dietetics, State University of Rio de Janeiro, Rio de Janeiro, Brazil

2   Department of Nutrition and Dietetics, Brazilian National Cancer Institute, Rio de Janeiro, Brazil

3   National Cancer Institute, Rua Equador 831, Rio de Janeiro, RJ 20220-410, Brazil

ERAS was introduced for elective colorectal surgery, but, because of positive results, the program has gained ground in other types of surgeries, such as orthopedics, urology, and gynecology. However, limited data are available for gynecologic cancer surgery. Also, a major challenge in healthcare is to incorporate new concepts into routine clinical practice [10].

Although it has been created risk scores that, when applied before surgery, can help the management of PONV [4, 11], it is unknown how the perioperative routine can impact the incidence of PONV in gynecologic cancer surgeries. In addition, most variables included in these risk scores are non-modifiable factors, whereas those related to perioperative care can be modified as recommended by the multimodal protocols [12].

Considering these aspects, the present study aimed to quantify the incidence of PONV in gynecologic cancer patients undergoing major surgery and determine the effect of unnecessary interventions that are known to increase the risk of PONV in an institution that does not conduct perioperative routines according to multimodal protocols.

Methods

Study design

The analyses are based on prospectively collected data of 82 female adult patients (18 years or older) with a diagnosis of cervical, ovarian, or endometrium tumor, enrolled in the Brazilian Cancer Institute (INCA – Instituto Nacional de Câncer José Alencar Gomes da Silva) who were submitted to open surgical treatment from 2011 to 2012 and undergoing general anesthesia. Patients who were submitted to laparoscopic and vaginal surgeries and those who did bowel resection during surgery were excluded.

The study protocol was approved by the Brazilian Cancer Institute (INCA – Instituto Nacional de Câncer José Alencar Gomes da Silva) ethics committee (CAAE number 01,052, 712.9.0000.5274). Patients were admitted into the study upon providing written formal authorization through a free and informed consent agreement.

Data collection

The follow-up started at the time of hospital admission for surgical procedure, and patients were followed up until the time of discharge. The researchers recorded the proceedings of the entire multidisciplinary team involved in perioperative care, and the clinical outcomes such as nausea, vomiting, and abdominal distension were assessed daily by the researchers.

The information related to age, smoking status, the tumor diagnosis, the perioperative conducts, and outcomes were collected from medical records. The staging was done according to the International Federation of Gynecology and Obstetrics (FIGO) system for tumor classification [13]. Confirmation of tumor site and tumor weight was obtained through histopathology reports.

Upon hospital admission, the patients were assessed for nutritional status by measuring their body mass index (BMI). Nutritional diagnosis was made according to World Health Organization guidelines for adults [14, 15], and according to Pan American Health Organization standards for the elderly [16]. Afterward, so as to homogenize the findings, the patients were classified in three groups: malnourished, eutrophic, and overweight. To calculate the BMI from patients with ovarian neoplasm, tumor weight was subtracted from body weight beforehand.

During the perioperative period, the following variables were recorded: use and type of MBP, length of preoperative fasting, consistency of early oral diet, technique and time of anesthesia, duration and type of surgery, use of opioids, antiemetics and antibiotics, and IH and short- and long-term complications. To classify intraoperative and postoperative IH volume, the cutoff points 10 mL/kg/h [17] and 30 mL/kg were used, respectively [18].

PONV were assessed in the immediate postoperative (IPO) and the first and second postoperative days (PO1 and PO2) on a binary scale (yes/no) by a trained nutritionist. Patients were considered nauseated in the IPO if they responded to the question, "Are you or have you felt nauseated after surgery?" Using similar questions, the vomiting episodes were assessed. In the PO1 or PO2, nausea and vomiting were assessed prospectively. Nausea and vomiting were considered as a binary outcome to be applicable to analysis.

A score formed with predictor variables of nausea and vomiting was built for the IPO, PO1, and PO2. The following variables were considered as predictors of nausea and vomiting: age (<50 year = 1, ≥50 year = 0), duration of operation (≥60 min = 1, <60 min = 0), use of postoperative opioids (yes = 1, no = 0), IH in the intraoperative period (≥10 mL/kg/h = 1, <10 mL/kg/h = 0), IH in the IPO (≥30 mL/kg = 1, <30 mL/kg = 0), IH in the PO1 (≥30 mL/kg = 1, <30 mL/kg = 0), IH in the PO2 (≥30 mL/kg = 1, <30 mL/kg = 0), MBP with mannitol (yes = 1, no = 0), smoking status (non-smoker = 1, smoker = 0), gender (once female gender is considered a risk factor for PONV and our population is composed only by women, all patients scored 1). Each factor contributed 1 to this score if present and 0 if absent in a patient.

Statistical analysis

The statistical analysis was performed using the packages "epicalc" [19] and "Epi" [20] included in the R software (v 3.2.0) [21].

In describing the sample, the data were expressed in percentages for the categorical variables and in mean for the

numeric variables; the incidence of nausea and vomiting was calculated according to their predictors and confounders.

A multiple logistic regression was fitted for the whole period and for each postoperative phase using nauseas, vomiting, nauseas or vomiting and both as outcomes and the score as exposure. The adjusted variables were selected by backward stepwise procedure and the best model was chosen according to Akaike information criterion. Variables included as potential confounders were regular use of ondansetron, use of ondansetron in the intraoperative period, performing pelvic or paraaortic lymphadenectomy, nutritional diagnosis, preoperative fasting time, consistency early oral diet, complications in the intraoperative period, short- and long-term non-digestive complications, anesthesic agent type, time under anesthesia, regular use of bromopride and metacloramide, and antibiotic use in the intraoperative and postoperative periods. After stepwise analysis, the final adjusted model included the variables: regular use of ondansetron, performing pelvic or paraaortic lymphadenectomy, preoperative fasting time, consistency early oral diet, complications in the intraoperative period, short-term non-digestive complications, anesthesic agent type, time under anesthesia, and antibiotic use in the postoperative period.

To estimate the discriminating power of a chosen model, a receiver operating characteristic (ROC) curve was plotted, and the area under the ROC curve (AUC) was calculated, which an AUC of 1.0 would represent a perfect discrimination.

Table 1 General characteristics of patients undergoing treatment for gynecological tumors (N = 82)

Variables	n	%
Nutritional diagnosis		
Eutrophic	22	26.8
Overweight	49	59.8
Malnourished	11	13.4
Tumor site		
Cervix	18	22.0
Endometrium	37	45.1
Ovary	27	32.9
Staging		
Stage I	35	42.7
Stage II	5	6.1
Stage III	17	20.7
Stage IV	2	2.4
No stage*	23	28.1

*Benign tumor or carcinoma in situ

Statistical significance was set at p value <0.05 and the confidence interval at 95 %.

Results

The mean age of patients enrolled in this study was 55 years (25 to 86); 22 % had a cervical tumor, 45 % an endometrium and 33 % an ovary tumor, and most of them (49 %) in early stages (I or II). The type of surgery performed in most patients was the type 1 total radical hysterectomy with or without

Table 2 Incidence of postoperative nausea and/or vomiting according to predictors and possible confounders

	Incidence (%)		
	Nausea	Vomiting	Nausea and vomiting
General	36.6	28.1	22.0
Predictors			
Age ≥50	18.3	13.4	12.2
Non-smoker	32.1	22.2	17.3
Use of postoperative opioids	11.0	12.2	7.3
IH in the IO ≥10 mL/kg/h	23.8	17.5	13.8
IH in the IPO ≥30 mL/kg	18.3	13.4	11.0
IH in the PO1 ≥30 mL/kg	15.9	12.2	9.8
IH in the PO2 ≥30 mL/kg	8.5	7.3	6.1
MBP with mannitol	12.2	11.0	8.5
Confounders*			
Regular use of ondansetron	15.9	11.0	8.5
IO use of ondansetron	22.0	19.5	15.9
Pelvic or paraaortic lymphadenectomy	4.9	6.1	2.4
Nutritional diagnosis			
Eutrophic	13.4	9.8	17.1
Overweight	17.1	15.9	3.7
Underweight	6.1	2.4	1.2
Consistency of early oral diet			
Clear liquid diet	31.7	20.7	7.3
Full liquid diet	3.7	4.9	12.2
Soft diet	1.2	2.4	2.4

IH intravenous hydration, *IO* intraoperative, *IPO* immediate postoperative, *PO1* first postoperative day, *PO2* second postoperative day, *MBP* mechanical bowel preparation

*Mean (minutes) of preoperative fasting time for patients who had nausea, vomiting, or both was 792, 802, and 819, respectively

salpingo-oophorectomy bilateral or unilateral (61 %). In relation to nutritional status, most of the patients were found to be overweight (Table 1).

Table 2 shows the incidence of postoperative nausea, vomiting, and both according to predictors used to build the score, and confounders used to adjust logistic regression. The incidence (%) of nausea, vomiting, and both, in the general population, was 36.6, 28.1, 22.0, respectively. According to the presence of predictors, the highest incidences were found in non-smokers and in patients who received 10 mL/kg/h or more of IH in IPO, ranging from 8.5 to 32.1 for nausea, 7.3 to 22.2 for vomiting, and 6.1 to 17.3 for both.

Table 3 shows the incidence of postoperative nausea, vomiting, and both according to score punctuation. The highest incidences were found in score 5, achieving 15.2 % for nausea and 10.1 % for vomiting.

The results of the adjusted model (Table 4) showed an increased risk of nausea, vomiting, nausea or vomiting, and both for each 1-point increase in the score punctuation. The relative risk was higher than 2.0 for vomiting in all periods and in the PO1, for instance.

Figure 1 shows the ROC curve for nausea, vomiting, nausea or vomiting, and both. All curves showed AUC higher than 0.75 which means a great discrimination of postoperative nausea and vomiting from the proposed group of variables that are potentially related to PONV.

Discussion

Nausea and vomiting are considered by many patients to be more distressing than postsurgical pain [22] with the cost of recovery increasing significantly in patients that develop PONV [23].

The high incidence of PONV in the study population is in accordance with the literature. Female patients undergoing gynecologic surgery are at high risk for development of PONV[4] ranging from 21 to 92 % [5, 24].

Despite some surgeries per se has been associated with PONV [25], its causal impact remains questionable. A high

Table 3 Incidence of postoperative nausea and/or vomiting according to score punctuation

Score	Incidence (%)		
	Nausea	Vomiting	Nausea and vomiting
3	2.5	1.3	1.3
4	7.6	5.1	3.8
5	15.2	10.1	10.1
6	6.3	7.6	3.8
7	6.3	3.8	3.8

Table 4 Risk of nausea or vomiting for each 1-point increase in the score punctuation

Outcome	Unadjusted		Adjusted[a]		p value[b]
	OR	CI 95 %	OR	CI 95 %	
Nausea					
All period[c]	**1.52**	**(1.01,2.30)**	**1.84**	**(1.03,3.27)**	0.028
IPO	1.89	(0.94,3.77)	1.85	(0.76,4.53)	0.159
PO1	**1.53**	**(1.03,2.28)**	1.48	(0.92,2.40)	0.099
PO2	1.39	(0.97,1.98)	**1.68**	**(1.00,2.84)**	0.040
Vomiting					
All period[c]	**1.66**	**(1.06,2.60)**	**2.12**	**(1.17,3.81)**	0.007
IPO	1.20	(0.46,3.10)	*		
PO1	1.66	(0.98,2.82)	**2.14**	**(1.05,4.39)**	0.019
PO2	1.20	(0.82,1.75)	1.26	(0.73,2.19)	0.409
Nausea and vomiting					
All period[c]	1.51	(0.95,2.4)	**1.99**	**(1.06,3.73)**	0.022
IPO	0.53	(0.12,2.25)	*		
PO1	1.63	(0.90,2.94)	2.02	(0.96,4.24)	0.039
PO2	1.28	(0.84,1.95)	1.29	(0.63,2.66)	0.485
Nausea or vomiting					
All period[c]	1.70	(1.12,2.60)	**1.99**	**(1.15,3.46)**	0.008
IPO	2.26	(1.13,4.54)	**2.57**	**(1.02,6.51)**	0.028
PO1	1.59	(1.08,2.34)	**1.65**	**(1.00,2.71)**	0.040
PO2	1.32	(0.94,1.84)	1.56	(0.99,2.46)	0.048

Bold values are significant

OR odds ratio, *CI 95 %* confidence interval of 95 %, *IPO* immediate postoperative, *PO1* first postoperative day, *PO2* second postoperative day, *AUC* area under the curve

[a] Adjusted by regular use of ondansetron, performing pelvic or paraaortic lymphadenectomy, preoperative fasting time, consistency early oral diet, complications in the intraoperative period, short-term non-digestive complications, anesthesic agent type, time under anesthesia, antibiotic use in the postoperative period

[b] p value from likelihood ratio test

[c] Presence or absence of nausea, vomiting, or both in the IPO or PO1 or PO2

*Algorithm did not converge

incidence of PONV after certain operations might be due not only by the type of surgery performed, but mainly by the involvement of high-risk patients, as in our study population, which consists of females, undergoing gynecologic laparotomies and who are more likely to receive postoperative opioids. In fact, in the Apfel's analysis of combined risk factors for PONV, the type of operation was not a strong independent predictor for this outcome[4]. In the present study, only patients undergoing open abdominal surgeries were included in the analysis, in order to eliminate the impact of the type of surgery on the results.

Our results confirm that, besides the established higher risk of PONV in non-smoker patients and in those aged below 50 years [9], aspects of perioperative routine were also

Fig. 1 ROC curve from logistic model for the proposed perioperative score as a predictor of postoperative nausea and vomiting in women with gynecological tumor
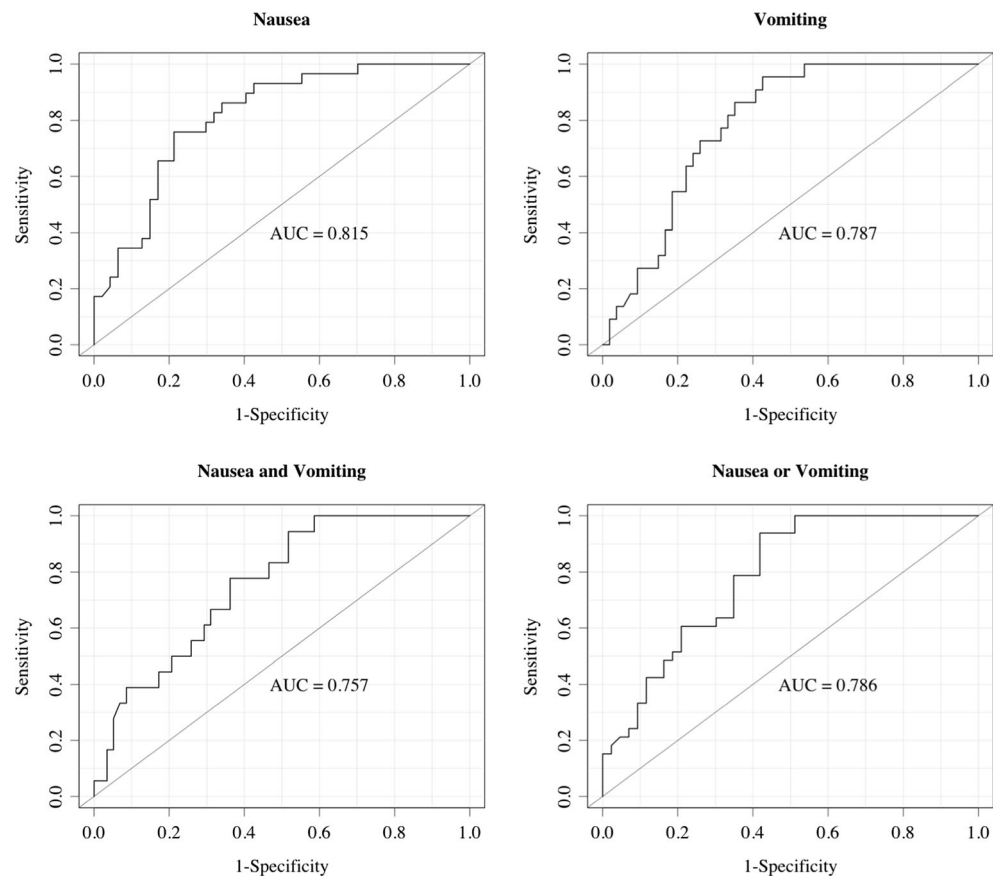
determinants of PONV and should be considered as predictors of increased risk for PONV: intraoperative IH above 10 mL/kg/h, IH in the IPO and PO1 higher than 30 mL/kg, the use of mannitol in the preoperative period, and postoperative use of opioids.

Excessive fluid replacement, when associated to reduced excretion of sodium, chloride, and water, which often occurs as a physiological response to trauma [26], causes generalized edema of tissues, with numerous clinical consequences. Therefore, it is considered as an important strategy for reducing the risk of nausea and vomiting to not over hydrate the patient in the perioperative period [27].

MBP is associated with dehydration and electrolyte disorders, hindering the balancing of fluids and electrolytes during the perioperative period, as well as a greater frequency of nausea, vomiting, paralytic ileum, abdominal discomfort, distension, and pain [28, 29]. However, an interview with oncology surgeons found that, although the literature does not show evidence for carrying out the MBP in gynecological surgery for cancer, 48 % perform MBP as routine [30]. Recently, the guidelines for the perioperative management in rectal/pelvic elective surgeries recommend that the MBP should be avoided in pelvic surgery [31].

Regarding analgesia, the intravenous opioid is still frequently used despite the inconvenience of increasing the incidence of nausea, vomiting, sedation, urinary retention, ileus,

and abdominal distension, which may delay the postoperative recovery [10, 32]. To prevent these symptoms, it is recommended multimodal analgesia with paracetamol and nonsteroidal anti-inflammatories. The epidural analgesia may be used as a rescue and the use of opioids only if pain control is not achieved with non-opioid drugs [10].

The patient risk for NVPO should be assessed preoperatively notwithstanding, according to the literature, routine administration of antiemetics is neither well established nor cost-effective [33]. The first consensus guideline that incorporated administration of prophylactic antiemetic treatment based on risk score stratification was published in 2003 [34]. Recently, the efficacy of PONV management, according to this consensus guideline, was examined comparing 300 adult surgical patients who underwent general anesthesia prior to institutional adoption of PONV management guideline with 301 adult surgical patients who underwent general anesthesia following adoption of the guideline. The institutional incidence of PONV was significantly reduced from 8.36 % to 3.01 % following guideline adoption. Although implementation of consensus PONV prevention guideline significantly reduced incidence at an institutional level, patients with three or more risk factors remain at risk for PONV. Once all patients who developed PONV had three or more risk factors, the reduction in incidence was attributable to an overall increase in preoperative antiemetic prophylaxis, with a concomitant increase in

multimodal treatment and a decrease in single modality treatment [35].

Some studies emphasize that the adoption of a risk-based PONV management program can reduce incidence of PONV institutionally [36, 37]. The inability of institutions to eradicate PONV in spite of the large body of scientific literature surrounding its management is a topic of current debate [38]. Some authors advocate a risk-based implementation of antiemetic administration [39], while other authors have suggested that a liberal antiemetic prophylaxis approach should be taken with all surgical patients [40].

Based on evidence suggesting that algorithms for PONV management are not universally applicable between different patient populations and institutions, Kranke et al. (2007) encourage the importance of establishing specific guidelines to each institution and target population and also the need for institutions in conducting studies for the purpose of evaluating their own guideline efficacy at the institutional level and to determine the areas for institution-specific improvement [41].

The aim of this study was not to create a specific risk factor for our population, as it has been done before, but to identify the main factors that determine PONV in gynecological oncologic surgery, in order to create multimodal strategies that could improve perioperative care.

This study has the following limitations: although PONV has been prospectively evaluated after each offered meal, it was measured by patient self-report, and not by a Likert scale, which prevented the assessment of symptom severity. Furthermore, the history of motion sickness or PONV was not collected. However, it is important to note that the modifiable predictors of PONV included in this study proved to be as important as non-modifiable risk factors cited above in determining PONV.

Therefore, considering that our study population has twice the risk of developing PONV for each predictor, three actions should be undertaken: (1) Create institutional guidelines abolishing modifiable variables, like MBP and the rational use of IH and opioids as routine; (2) consider antiemetic prophylaxis for virtually all women undergoing surgery for gynecological cancer; and (3) perform temporal evaluation of the effectiveness of the measures taken.

Author contribution Chaves GV conceived of and coordinated the study, Costa AF carried out the statistical analyses, and Souza DS conducted collection data. All authors contributed to the writing and reviewing of the paper and approved the final version.

Compliance with ethical standards The study protocol was approved by the Brazilian Cancer Institute (INCA – Instituto Nacional de Câncer José Alencar Gomes da Silva) ethics committee (CAAE number

01,052,712.9.0000.5274). Patients were admitted into the study upon providing written formal authorization through a free and informed consent agreement.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Peixoto AJ, Peixoto Filho AJ, Leães LF, Celich MF, Barros MAV (2000) Efficacy of prophylactic droperidol, ondansetron or both in the prevention of post operative nausea and vomiting in major gynaecological surgery. A prospective, randomized, double-blind clinical trial. Eur J Anaesthesiol 17:611–615
2. Gupta A, Wu CL, Elkassabany N, Krug CE, Parker SD, Fleisher LA (2003) Does the routine prophylactic use of antiemetics affect the incidence of post discharge nausea and vomiting following ambulatory surgery? A systematic review of randomized controlled trials. Anesthesiology 99(2):488–495
3. Habib AS, El-Moalem HE, Gan TJ (2004) The efficacy of the 5-HT3 receptor antagonists combined with droperidol for PONV prophylaxis is similar to their combination with dexamethasone. A meta-analysis of randomized controlled trials. Can J Anaesth 51(4):311–319
4. Apfel CC, Läärä E, Koivuranta M, Greim CA, Roewer N (1999) A simplified risk score for predicting postoperative nausea and vomiting: conclusions from cross-validations between two centers. Anesthesiology 91:693–700
5. Woodhouse A, Mather LE (1998) The effect of duration of dose delivery with patient-controlled analgesia on the incidence of nausea and vomiting after hysterectomy. Br J Clin Pharmacol 45:57–62
6. Cohen MM, Ducan PG, DeBoer DP, Tweed WA (1994) The postoperative interview: assessing risk factors for nausea and vomiting. Anesth Analg 78(1):7–16
7. Kenny GN (1994) Risk factors for postoperative nausea and vomiting. Anaesthesia 49:6–10
8. Sinclair DR, Chung F, Mezei G (1999) Can postoperative nausea and vomiting be predicted? Anesthesiology 91(1):109–118
9. Apfel CC, Greim CA, Haubitz I, et al. (1998) The discriminating power of a risk score for postoperative vomiting in adults undergoing various types of surgery. Acta Anaesthesiol Scand 42(5):502–509
10. Fearon KC, Ljungqvist O, Von Meyenfeldt M, et al. (2005) Enhanced recovery after surgery: a consensus review of clinical care of patients undergoing colonic resection. Clin Nutr 24:466–477
11. Wu YH, Sun HS, Wang ST, Tseng CA (2015) Applicability of risk scores for postoperative nausea and vomiting in a Taiwanese population undergoing general anaesthesia. Anaesth Intensive Care 43(4):473–478
12. Gadducci A, Cosio S, Spirito N, Genazzani AR (2010) The perioperative management of patients with gynaecological cancer undergoing major surgery: a debated clinical challenge. Crit Rev Oncol Hematol 73(2):126–140
13. Mutch DG (2009) The new FIGO staging system for cancers of the vulva, cervix, endometrium, and sarcomas. Gynecol Oncol 115:325–328
14. World Health Organization (1995) Physical status: the use and interpretation of anthropometry. WHO, Geneva
15. World Health Organization (2004) Obesity: preventing and managing the global epidemic. WHO, Geneva
16. Organización Panamericana de la Salud (2001) XXXVI Reunión del Comité Asesor de Investigaciones en Salud. Encuesta

Multicéntrica Salud, Bienestar y envejecimiento (SABE) en América Latina y el Caribe - Informe Preliminar. División de promoción y protección de la salud (HPP). Washington, D.C.: Organización Panamericana de la Salud (OPAS)

17. MacKay G, Fearon K, McConnachie A, Serpell MG, Molloy RG, O'Dwyer PJ (2006) Randomized clinical trial of the effect of postoperative intravenous fluid restriction on recovery after elective colorectal surgery. Br J Surg 93:1469–1474

18. Aguilar-Nascimento JE, Bicudo-Salomão A, Caporossi C, Silva RM, Cardoso EA, Santos TP (2008) Enhancing surgical recovery in central-west Brasil: the ACERTO protocol results. e-SPEN 3: e78–e83

19. Chongsuvivatwong V (2012). epicalc: Epidemiological calculator. R package version 2.15.1.0. Available online: http://CRAN.R-project.org/package=epicalc

20. Robin X, Turck N, Hainard A, et al. (2011) pROC: an open-source package for R and S+ to analyze and compare ROC curves. BMC Bioinformatics 12:77

21. R Development Core Team (2014). R: A language and environment for statistical computing. The R Foundation for Statistical Computing. Available online: http://www.R-project.org/

22. Macario A, Weinger M, Carney S, Kim A (1999) Which clinical anesthesia outcomes are important to avoid? The perspective of patients. Anesth Analg 89(3):652–658

23. Parra-Sanchez I, Abdallah R, You J, et al. (2012) A time-motion economic analysis of postoperative nausea and vomiting in ambulatory surgery. Can J Anaesth 59(4):366–375

24. McKenzie R, Kovac A, O'Connor T, et al. (1993) Comparison of ondansetron versus placebo to prevent postoperative nausea and vomiting in women undergoing ambulatory gynecologic surgery. Anesthesiology 78:21–28

25. Camu F, Lauwers MH, Verbessem D (1992) Incidence and aetiology of postoperative nausea and vomiting. Eur J Anaesthesiol 9:25–31

26. Macafee DA, Allison SP, Lobo DN (2005) Some interaction between gastrointestinal function and fluid and eletrolyte homeostasis. Curr Opin Clin Nutr Metab Care 8:197–203

27. Hausel J, Nygren J, Thorell A, Lagerkranser M, Ljunggvist O (2005) Randomized clinical trial of the effects of oral preoperative carbohydrates on postoperative nausea and vomiting after laparoscopic cholecystectomy. Br J Surg 92(4):415–421

28. Gründel K, Schwenk W, Böhm B, Muller JM (1997) Improvements in mechanical bowel preparation for elective colorectal surgery. Dis Colon rectum 40:1348–1352

29. Jung B, Lannerstad O, Pahlman L, Arodell M, Unosson M, Nilsson E (2007) Preoperative mechanical preparation of the colon: the patient's experience. BMC Surg 7:5

30. Wells T, Plante M, McAlpine JN (2011) Communities of practice groups on behalf of the Society of Gynecologic Oncologists of Canada. Preoperative bowel preparation in gynecologic oncology: a review of practice patterns and an impetus to change. Int J Gynecol Cancer 21(6):1135–1142

31. Nygren J, Thacker J, Carli F, et al. (2013) Guidelines for perioperative care in elective rectal/pelvic surgery: enhanced recovery after surgery (ERAS) society recommendations. World J Surg 37: 285–305

32. Jorgensen H, Wetterslev J, Moiniche S, Dahl JB (2000). Epidural local anaesthetics versus opioid-based analgesic regimens on postoperative gastrointestinal paralysis, PONV and pain after abdominal surgery. Cochrane Database Syst Rev CD001893.

33. Fisher DM (1997) The "big little problem" of postoperative nausea and vomiting: do we know the answer yet? Anesthesiology 87: 1271–1273

34. Gan TJ, Diemunsch P, Habib AS, et al. (2014) Consensus guidelines for managing postoperative nausea and vomiting. Anesth Analg 118(1):85–113

35. Myklejord DJ, Yao L, Liang H, Glurich I (2012) Consensus guideline adoption for managing postoperative nausea and vomiting. WMJ 111(5):207–213

36. Biedler A, Wermelt J, Kunitz O, et al. (2004) A risk adapted approach reduces the overall institutional incidence of postoperative nausea and vomiting. Can J Anesth 51(1):13–19

37. Pierre S, Corno G, Beanias H, Apfel CC (2004) A risk score-dependent antiemetic approach effectively reduces postoperative nausea and vomiting—a continuous quality improvement initiative. Can J Anesth 51(4):320–325

38. Kranke P (2011) Effective management of postoperative nausea and vomiting: let us practise what we preach! Eur J Anaesthesiol 28(3):152–154

39. Pierre S (2000) Risk scores for predicting postoperative nausea and vomiting are clinically useful tools and should be used in every patient: pro—'don't throw the baby out with the bathwater. Eur J Anaesthesiol 28(3):160–163

40. Eberhart LH, Morin AM (2011) Risk scores for predicting postoperative nausea and vomiting are clinically useful tools and should be used in every patient: con—'life is really simple, but we insist on making it complicated. Eur J Anaesthesiol 28(3):155–159

41. Kranke P, Eberhart LH, Gan TJ, Roewer N, Tramer MR (2007) Algorithms for the prevention of postoperative nausea and vomiting: an efficacy and efficiency stimulation. Eur J Anaesthesiol 24(10):856–867