Anesthesiology
1999; 91:693–700
© 1999 American Society of Anesthesiologists, Inc.
Lippincott Williams & Wilkins, Inc.

A Simplified Risk Score for Predicting Postoperative Nausea and Vomiting

Conclusions from Cross-validations between Two Centers

Christian C. Apfel, M.D., Esa Läärä, Ph.D.,† Merja Koivuranta, M.D., Ph.D.,‡ Clemens-A. Greim, M.D.,§ Norbert Roewer, M.D.‖*

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021

Background: **Recently, two centers have independently developed a risk score for predicting postoperative nausea and vomiting (PONV). This study investigated (1) whether risk scores are valid across centers and (2) whether risk scores based on logistic regression coefficients can be simplified without loss of discriminating power.**

Methods: **Adult patients from two centers (Oulu, Finland: n = 520, and Wuerzburg, Germany: n = 2202) received inhalational anesthesia (without antiemetic prophylaxis) for various types of surgery. PONV was defined as nausea or vomiting within 24 h of surgery. Risk scores to estimate the probability of PONV were obtained by fitting logistic regression models. Simplified risk scores were constructed based on the number of risk factors that were found significant in the logistic regression analyses. Original and simplified scores were cross-validated. A combined data set was created to estimate a potential center effect and to construct a final risk score. The discriminating power of each score was assessed using the area under the receiver operating characteristic curves.**

Results: **Risk scores derived from one center were able to predict PONV from the other center (area under the curve = 0.65–0.75). Simplification did not essentially weaken the discriminating power (area under the curve = 0.63–0.73). No center effect could be detected in a combined data set (odds ratio = 1.06, 95% confidence interval = 0.71–1.59). The final score consisted of four predictors: female gender, history of motion sickness (MS) or PONV, nonsmoking, and the use of postoperative opioids. If none, one, two, three, or four of these risk factors were present, the incidences of PONV were 10%, 21%, 39%, 61% and 79%.**

Conclusions: **The risk scores derived from one center proved valid in the other and could be simplified without significant loss of discriminating power. Therefore, it appears that this risk score has broad applicability in predicting PONV in adult patients undergoing inhalational anesthesia for various types of surgery. For patients with at least two out of these four identified predictors a prophylactic antiemetic strategy should be considered. (Key words: Logistic regression model; postoperative nausea and vomiting; receiver operating characteristic curve; risk factors; risk score.)**

GENERAL anesthesia using volatile anesthetics is associated with an average incidence of postoperative nausea and vomiting (PONV) ranging between 20% and 30%.[1] It has been suggested that this may increase patients' discomfort and also increase costs (*e.g.*, antiemetics, readmission) and unwarranted side effects (*e.g.*, pulmonary aspiration).[2] PONV is thought to be multifactorial, involving anesthetic, surgical, and individual risk factors.[1–3] A few studies have tried to quantify the relative impact of risk factors[4–6] and to set up a risk model for the prediction of PONV.[4,7,8] If such a model can be shown to have general applicability, it could provide a rational basis to decide who might benefit from prophylactic antiemetic therapy.[9]

An initial step was to construct a risk table for PONV based on patient-related factors (*e.g.*, gender, history).[4] However, because this study was restricted to one type of anesthesia and surgery, the relative impact was not quantified. This limitation was overcome by a prospective survey in Oulu, Finland, with different types of anesthesia and surgery, which revealed that the most

* Research Fellow, Department of Anesthesiology, University of Wuerzburg.

† Professor of Statistics, Department of Mathematical Sciences/Statistics, University of Oulu.

‡ Senior Anesthesiologist, Department of Anesthesiology, University of Oulu.

§ Senior Anesthesiologist, Department of Anesthesiology, University of Wuerzburg.

‖ Professor of Anesthesiology and Chair, Department of Anesthesiology, University of Wuerzburg.

Received from the Department of Anesthesiology, University of Wuerzburg, Wuerzburg, Germany; and the Department of Mathematical Sciences/Statistics, University of Oulu, and the Department of Anesthesiology, Oulu University Hospital, Oulu, Finland. Submitted for publication November 30, 1998. Accepted for publication May 7, 1999. Support was provided solely from institutional and/or departmental sources.

Address reprint requests to Dr. Apfel: Department of Anesthesiology, University of Wuerzburg, Josef-Schneider-Str. 2, D-97080 Wuerzburg, Germany. Address electronic mail to: apfel@anaesthesie.uni-wuerzburg.de

Table 1. Patient Criteria for the Study Population

Inclusion criteria
Scheduled for elective operations under general anesthesia
Adult male and female patients ≥ 18 yr
Weight ≥ 40 kg and < 150 kg
Height ≥ 1.40 m and < 2.10 m
Body mass index > 15 kg/m^2 and < 40 kg/m^2
No contraindications for drugs used in the study
Exclusion criteria
Preoperative or intraoperative use of drugs with antiemetic properties
Incomplete or inconsistent data
Regional anaesthesia alone or combined with general anaesthesia

important predictors were patient-specific.[7] The authors also reported a simplified risk score that was based on the number of equally weighted risk factors present (0–5). Recently, the incidences of postoperative nausea and postoperative vomiting were studied separately after different types of otolaryngologic surgery in Wuerzburg, Germany.[8] Again, patient-specific predictors were most relevant, so an operation-independent risk score for postoperative vomiting was constructed[8] that was later demonstrated to be applicable in patients undergoing general and ophthalmologic surgery.[10] Because validation of such predictive scores in other centers is required in other centers,[9] two centers performed cross-validation in order to answer the following questions:

Can a risk score derived from one center predict PONV in an individual from another center with a similar discriminating power?

Does a simplification of a risk score for PONV retain its discriminating power?

How accurate are calibration curves of a risk score in predicting the incidence of PONV in risk groups from another center?

In a combined data set, what are the most important predictors for a final score, and what is the impact of a possible center effect?

Materials and Methods

Origin of Data

The analyses are based on prospectively collected data of 520 and 2,202 adult patients (age ≥ 18 yr) who underwent general anesthesia with volatile anesthetics. The data of 520 patients are a subset of the 1,107 patients of the previous survey in Oulu[7]; the data of 2,202 patients were taken from two other studies conducted in Wuerzburg.[8,10] The latter studies applied the same eligibility criteria as the present study (table 1), whereas the Oulu survey initially included a broader spectrum of patients (covering for example children or those receiving regional anesthesia). The distribution of patient characteristics and other variables are presented in table 2.

Anesthesia

All selected patients received an inhalational anesthetic technique as previously described.[7,8] This included a benzodiazepine for premedication on the morning of the operation, induction with thiopental 3–5 mg/kg and either fentanyl up to 2 μg/kg or alfentanil up to 20 μg/kg, and the use of a volatile anesthetic (isoflurane, enflurane, or sevoflurane). No prophylactic antiemetics were given. Postoperative pain was treated with nonsteroidal analgetic drugs or opioids such as oxycodone or tramadol if needed (table 2).

Outcome

Although both centers originally performed their studies without knowledge of each other, the assessment of the outcome was similar. Postoperative nausea was assessed at 2 h on a binary scale (yes/no) by a trained nurse and at 24 h on an 11-point numeric scale (0–10) by a trained physician (the principal investigator of each cen-

Table 2. Distribution of Patient Characteristics and Other Variables in Both Centers

	Oulu (n = 520)	Wuerzburg (n = 2,202)
Overall incidence of PONV	55.6 (289)	31.3 (689)
Age (yr)	46 (35–57)	52 (36–64)
Female	71.0 (369)	42.8 (942)
History of motion sickness or PONV	51.3 (267)	18.9 (416)
Nonsmoker	75.0 (390)	71.2 (1568)
Use of postoperative opioids	81.3 (423)	10.2 (225)
Type of surgery		
Orthopedic	5.6 (29)	8.9 (196)
Ophthalmology	8.8 (46)	15.5 (342)
Otolaryngology	12.9 (67)	38.9 (856)
Laparoscopy	32.5 (169)	2.5 (56)
Laparotomy	14.8 (77)	6.3 (139)
Other	25.4 (132)	27.8 (613)
Duration (h:min)	1:58 (1:17–2:25)	1:54 (1:10–2:38)

Data are presented as percentage of patients (number) or median (lower-upper quartiles).

PONV = postoperative nausea and vomiting.

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021

ter or one or two of his or her colleagues). Patients were considered nauseated if they responded to the question, "Are you or have you felt nauseated in the last 2 h?" or if postoperative nausea was reported to be greater than zero on the 11-point scale during the 24-h assessment with the question, "Have you felt nauseated since your discharge from the postanesthetic care unit and if so, what would be the average level of nausea you have felt until now on a 0 to 10 scale?" For the same intervals the number of episodes of postoperative vomiting was recorded. Again, patients were considered to have vomited if postoperative vomiting occurred at least once within the first 2 h or within the following 22 h. Patients who had either postoperative nausea or postoperative vomiting in either of these two periods were considered to have had PONV. PONV was considered as a binary outcome to be applicable to logistic regression analysis.

Predictors

The following variables were considered in the analysis: gender (female = 1, male = 0), age (< 50 yr = 1, ≥ 50 yr = 0), smoking status (nonsmoker = 1, smoker = 0), MS or PONV in the patient history (yes = 1, no = 0), duration of operation (< 60 min = 0, ≥ 60 min = 1), use of postoperative opioids (yes = 1, no = 0), and type of surgery (orthopedic, ophthalmologic, otolaryngologic, laparoscopic, laparotomic, and other). Possible one-way interactions were also evaluated. Other variables (*e.g.*, body mass index, the type and dosage of volatile anesthetics), which previously have been shown not to contribute significantly to the prediction of postoperative nausea or postoperative vomiting,[6–8,11] were not considered in the current analysis.

Analysis

The most predictive factors were chosen by fitting a logistic regression model using a forward selection procedure ($P < 0.05$ to enter). In this model the estimated probability of PONV, denoted by P, depends on the score S_{coeff} according to the formula

$$P = (1 + \exp(-S_{coeff}))^{-1}, \qquad (1)$$

in which $S_{coeff} = b_0 + b_1x_1 + \ldots + b_kx_k$ is a weighted sum of the values $x_1, \ldots, x_k$ of k risk factors or predictors, each coded as 1 if present and 0 if absent in a patient, with $b_1, \ldots, b_k$ as the weights or estimated regression coefficients, each describing the log-odds-ratio associated with the corresponding factor (so that the corresponding odds ratio is obtained $OR_j = \exp(b_j)$ for factor j). b_0 is the intercept term describing the baseline log-odds of PONV, that is, $P_0 = (1 + \exp(-b_0))^{-1}$ is the estimated baseline risk of PONV in a patient with no risk factors.

To estimate the discriminating power of a chosen model, a receiver operating characteristic (ROC) curve was plotted. A ROC curve demonstrates the relationship of sensitivity and specificity at various points or decision criteria; that is, at what level of the score patients will be classified as potential vomiters or nonvomiters. The areas under the ROC curves (AUCs) were calculated as previously described[8] and are estimates of how well patients who vomited will be discriminated from patients who did not vomit by the score (discriminating power). An AUC of 1.0 would represent a perfect discrimination; an AUC of 0.5 refers to a case with no discrimination at all. The 95% confidence intervals of the AUC were approximated according to the formula

$$\mathrm{AUC} \pm 1{,}96 \times (\mathrm{AUC} \times (1 - \mathrm{AUC})/m)^{1/2} \qquad (2)$$

where m is the size of the smaller of the two groups: those with postoperative vomiting and those without postoperative vomiting.

The calibration[12] or accuracy of a score in predicting the probability of PONV applied to the patients of the other center was evaluated by fitting a linear regression model relating the predicted probabilities and the observed proportions of PONV in five groups sorted by increasing predicted probabilities. The slope and the intercept of the fitted regression line show whether the score generally or in a certain range under- or overestimates the occurrence of PONV. Given that the relation is truly linear a slope of 1 (45 degrees) with an intercept of 0 represents perfect calibration.

In order to answer the questions posed in the introduction, the following approaches were chosen: For each center a score (generically denoted as S_{coeff}) based on the regression coefficients of the fitted logistic model (according to formula [1]) was developed to estimate the probability of PONV following the same principles as previously described for postoperative vomiting.[8] A score derived in that way from the data collected in Oulu is identified as *score* O_{coeff}; a score derived from the data collected in Wuerzburg is shown as *score* W_{coeff}. The discriminating power of both scores was tested by plotting ROC curves and calculating their AUCs. This calculation was applied to both the data from which the score was derived and the data of the other center for comparison.

Two corresponding simplified scores were con-

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021

structed, each based on equally weighted factors instead of the estimated logistic coefficients (*score* O_{fact} and *score* W_{fact}). Equally weighted factors means that each factor that has been shown to be significant in the score derived from the logistic regression analysis was given a coefficient of 1, leading to the following type of score: $S_{fact} = x_1 + \ldots + x_k$. Each factor contributes 1 to this score if present and 0 if absent in a patient. Hence, the number of risk factors present provides the individual value of this simplified score. Again, ROC curves were plotted and the AUCs of the simplified scores were compared with the AUCs achieved with the scores based on regression coefficients. Thus, a total of $2 \times 2 \times 2 = 8$ AUCs were calculated.

The simplified scores were each entered in a second procedure as a linear variable in a logistic regression model on their original data set so that for each risk group an expected incidence P_{fact} of PONV (based on a simplified score S_{fact}) could be estimated according to the formula

$$P_{fact} = [1 + \exp(-a_0 - a_1 S_{fact})]^{-1} \quad (3)$$

where a_0 and a_1 are estimated regression coefficients pertaining to this prediction model. The patients of the other center were classified according to the simplified risk score and in five ordered groups the theoretical incidences were plotted against the actual incidences in the appropriate calibration curves.

To ensure an equal representation of both centers all the 520 patients from Oulu and 520 patients randomly chosen out of the 2,202 from Wuerzburg were included in a combined data set of 1,040 patients. According to the method previously described the estimated regression coefficients of the most relevant factors for the prediction of PONV, as emerging from the combined data, were used to develop a new risk score (*score* OW_{coeff}), and a variable indicating the origin of the center was introduced to assess the remaining potential impact for the prediction of PONV. Finally, *score* OW_{coeff} was simplified by forming the equally weighted sum score with the four most relevant factors (*score* OW_{fact}), and its discriminating power was examined by calculating the AUC of the ROC.

Results

The prevalence and distributions of most factors, as well as the incidence of PONV, appeared to be different between the two centers (table 2). Only the duration of surgery, the age of the patients, and the proportion of nonsmokers were similar. The incidence of PONV still appeared to be different when corrected for any *single* variable such as female gender, prior history of MS or PONV, nonsmoking, postoperative opioids, and type of operation (table 3).

Table 3. Incidence of Postoperative Nausea and Vomiting in Both Centers According to the Predictors or the Type of Operation

	Oulu	Wuerzburg
Gender		
Female	63 (58–68)	47 (44–50)
Male	38 (30–46)	20 (18–22)
History of motion sickness or PONV		
Yes	66 (61–72)	57 (53–62)
No	44 (38–50)	25 (23–27)
Nonsmoker		
Yes	62 (57–66)	36 (33–38)
No	38 (29–46)	21 (17–24)
Use of postoperative opioids		
Yes	59 (55–64)	37 (31–43)
No	39 (29–49)	31 (29–33)
Type of surgery		
Orthopedic	52 (32–71)	33 (27–40)
Ophthalmology	33 (19–47)	28 (23–33)
Otolarygology	49 (37–62)	27 (24–30)
Laparoscopy	57 (49–64)	38 (24–51)
Laparotomy	75 (65–85)	34 (26–42)
Other	55 (46–63)	38 (34–42)

Data are presented as percent of patients with PONV (95% confidence interval).

PONV = postoperative nausea and vomiting.

The most predictive risk factors derived from Oulu were female gender, prior history of MS or PONV, nonsmoking, and use of opioids (table 4). For all these risk factors the adjusted odds ratios in the multivariate model were approximately 2. For Wuerzburg the important risk factors again included female gender, prior history of MS or PONV, and nonsmoking but not the use of postoperative opioids. In contrast to Oulu, age, duration, and the interaction of male gender and prior history of MS or PONV were additional significant predictors. If ROC curves were plotted by applying the developed risk scores to its original data, the AUC of *score* O_{coeff} and *score* W_{coeff}, that is, those based on estimated logistic regression coefficients, were 0.69 and 0.75, respectively (table 5). If the scores were applied to the other center, the AUC of the *score* O_{coeff} and *score* W_{coeff} were 0.69 and 0.65, respectively (table 5). Thus the *score* O_{coeff} and *score* W_{coeff} resulted in a mean AUC of 0.69 and 0.70 if applied to both data sets.

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021

Table 4. Regression Coefficients (Standard Errors) and Odds Ratios (95% Confidence Intervals) Derived from the Logistic Analysis (Stepwise Forward Selection Procedure) of Oulu, Wuerzburg, and the Combined Data Set

	Oulu		Wuerzburg		Combined Data	
	Coefficient (SE)	Odds Ratio (95% CI)	Coefficient (SE)	Odds Ratio (95% CI)	Coefficient (SE)	Odds Ratio (95% CI)
Age	—	—	0.71 (0.10)	2.03 (1.67–2.47)	—	—
Female gender	0.82 (0.21)	2.27 (1.50–3.43)	1.27 (0.12)	3.56 (2.81–4.51)	1.27 (0.19)	3.57 (2.47–5.16)
Prior history of motion sickness or PONV	0.67 (0.19)	1.95 (1.35–2.84)	0.62 (0.13)	1.86 (1.44–2.40)	0.65 (0.18)	1.92 (1.36–2.71)
Nonsmoking	0.85 (0.22)	2.34 (1.52–3.60)	0.71 (0.12)	2.03 (1.61–2.57)	0.72 (0.16)	2.05 (1.49–2.83)
Postoperative opioids	0.91 (0.24)	2.48 (1.55–3.98)	—	—	0.78 (0.14)	2.18 (1.65–2.89)
Duration of surgery	—	—	0.58 (0.11)	1.79 (1.44–2.22)	—	—
Male gender	—	—	0.97 (0.24)	2.64 (1.65–4.22)	0.76 (0.31)	2.14 (1.16–3.97)
Prior history of MS or PONV Intercept	−2.07 (0.33)	0.13 (0.07–0.24)	−2.86 (0.16)	0.06 (0.04–0.09)	−2.28 (0.19)	0.10 (0.07–0.15)

The age and the duration of surgery were dichotomized (<50 yr = 1, ≥50 yr = 0 and < 60 min = 0, ≥ 60 min = 1). Presence of a risk factor was generally coded 1 and the absence as 0.

CI = confidence interval; PONV = postoperative nausea and vomiting.

The AUC of the simplified scores, that is, those based on counting the number of significant risk factors present, was similar to the AUC of the previously described scores and did not lead to a relevant decrease in discriminating power (table 5). The simplified *score* O_{fact} and *score* W_{fact} applied to the data of Wuerzburg and Oulu resulted in calibration lines having slopes of 0.91 and 0.86 and intercepts of 0.01 and 0.13, respectively (fig. 1).

The analysis of the combined data set resulted in five significant predictors (table 4). If a center variable was included in a logistic model the odds ratio (lower–upper 95% confidence limit) was 1.06 (0.71–1.59) and thus had practically no impact on the predicted incidence of PONV (table 6). For the construction of *score* OW_{fact} the one-way interaction of male gender by prior history of MS or PONV was dropped, as this did not have a significant impact on the AUC (data not shown). Thus, the remaining four risk factors for *score* OW_{fact} were female gender, prior history of MS or PONV, nonsmoking, and the use of postoperative opioids. As depicted in the ROC curve this score leads to an AUC of about 0.75 with a best overall predictive value of about 0.71 (fig. 2). According to *score* OW_{fact} the estimated probability of PONV was 10, 21, 39, 61, and 78 in the joint data set if no, one, two, three, or four risk factors were present.

Discussion

The analysis shows that a risk score for PONV derived in one center could be applied to another center, and that a simplification of such a score, based only on counting how many of the four significant risk factors were present, had a similar discriminating power to a score based on regression coefficients estimated in a logistic regression model. In the combined data set, the four most important predictors were female gender, prior history of MS or PONV, nonsmoking, and the use of postoperative opioids. Although the distribution of risk factors as well as the incidences of PONV, even if adjusted for any *single* variable, appeared to be quite different in both centers, it could be demonstrated that the center had no impact on the incidence of PONV if the *four* relevant predictors were all taken into account. Thus, the final score may reliably predict PONV in a wide

Table 5. Area under the ROC Curves (with 95% Error Margins) of the Original and Simplified Scores Derived from and Applied to Both Centers

	AUC When Score Is Applied to:		
	Data from Oulu	Data from Wuerzburg	Mean
Oulu using			
Coefficients	0.693 (0.053)	0.685 (0.035)	0.689 (0.044)
Factors	0.683 (0.053)	0.700 (0.034)	0.692 (0.044)
Wuerzburg			
Coefficients	0.649 (0.055)	0.746 (0.032)	0.698 (0.044)
Factors	0.627 (0.056)	0.731 (0.033)	0.679 (0.045)
Mean	0.663 (0.054)	0.716 (0.033)	0.690 (0.044)

Note: The 95% confidence limits, *e.g.,* for the upper left hand corner cell are obtained: 0.693 ± 0.053 = 0.640 to 0.746 and analogously for the remaining cells.

AUC = area under the receiver operating characteristic curve.

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021

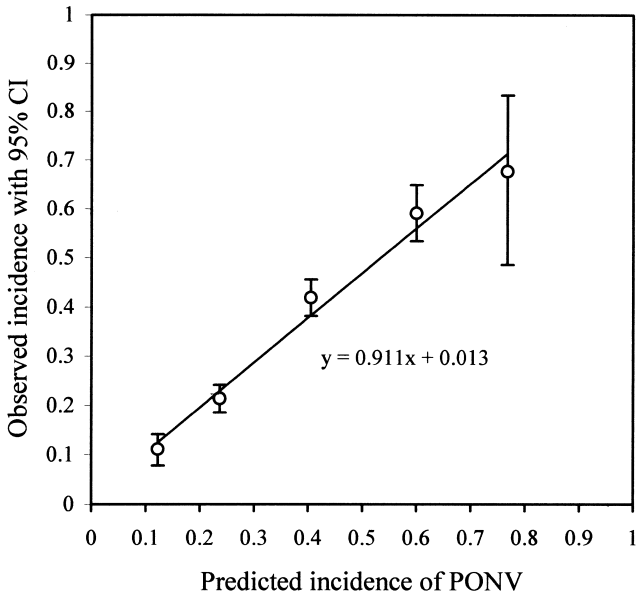

Fig. 1. Calibration plot of the predicted and actual incidences of postoperative nausea and vomiting (PONV) with 95% confidence intervals (CI). The predicted risk is based on the analysis of 520 patients from Oulu, Finland, and applied to the incidence of 2,202 patients from Wuerzburg, Germany.

spectrum of patients undergoing various types of surgery during inhalational anesthesia.

Special attention was given to the type of operation. Surely there is an *association* between the type of operation and PONV.[1–3,13] However, its causal impact on PONV remains questionable, because a high incidence of PONV after certain operations might well be caused by the involvement of high-risk patients (*e.g.*, in gynecologic laparotomies, the patients are females and are also more likely to receive postoperative opioids). Our analysis of the combined dataset confirms that the type of operation is not a strong independent predictor for PONV, which is consistent with our previous studies.[7,8] Nevertheless, we reviewed the literature on PONV in an attempt to find evidence for the assumed impact of the type of operation on PONV.[14–18] However, apart from the observation that some operations apparently are being associated with a higher incidence of PONV than others, it was and still is unclear whether this was caused by the different anesthetic agents,[19] the different lengths of operation,[15] or the operation itself.[17] Even large prospective studies using logistic regression analyses have conflicting results.[6,11] In view of our results, it seems more appropriate to base risk prediction on the described risk score rather than a certain type of operation, as there is not sufficient evidence for an assumed *causal* impact of the type of operation on PONV.

The use of *postoperative* opioids as a predictor for PONV may be questioned. We have included this predictor in the analyses because the use of narcotics in daily practice is often foreseeable and depends very much on the institutional analgetic policy as well as on the duration and type of operation.[20]

Although the raw data appeared to be quite different, there were three factors that were significant in both centers, namely female gender, prior history of MS or PONV, and nonsmoking. The use of postoperative opioids was only significant in Oulu but not in Wuerzburg. This may well be a result of different approaches to postoperative pain management. In Oulu more patients received postoperative opioids compared with Wuerzburg (80% *vs.* 10%) and the analgesic dosage was much higher (20 mg oxycodone *vs.* 100 mg tramadol). The discriminating power of *score* O_{coeff} appeared to be independent of the center, whereas the discriminating power of *score* W_{coeff} was better if it was applied to its own data set than if it was applied to data from the other center. One reason might be that more risk factors were derived from Wuerzburg than from Oulu, which may also explain why the mean AUC of the scores from

Table 6. Results of a Logistic Regression Analysis of 520 Patients Selected from Each Center

Variable	b	SE	b/SE	*P* Value	Odds Ratio	Confidence Interval of Odds Ratio
Female gender	1.268	0.189	6.71	<0.0001	3.55	2.46–5.14
Prior history of motion sickness or PONV	0.647	0.177	3.66	0.0003	1.91	1.35–2.70
Nonsmoking	0.718	0.163	4.40	<0.0001	2.05	1.49–2.82
Postoperative opioids	0.740	0.120	6.17	0.0002	2.10	1.42–3.10
Male by prior history of MS or PONV	0.765	0.314	2.44	0.0148	2.15	1.16–3.97
Center	0.060	0.205	0.29	0.7691	1.06	0.71–1.59
Intercept	−2.282	0.189	−12.07	<0.0001	0.10	0.07–0.15

b = regression coefficient of the variable; SE = standard error of b; PONV = postoperative nausea and vomiting; MS = motion sickness.

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021

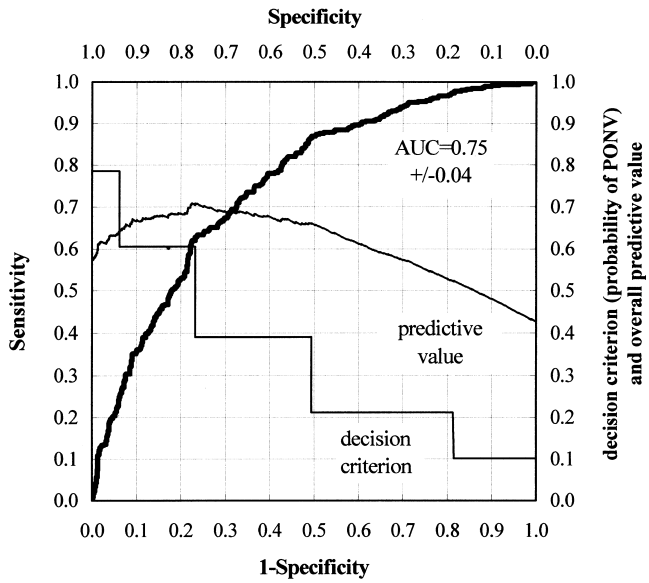

Fig. 2. Receiver operating characteristic curve in 1,040 patients from both centers for the prediction of postoperative nausea and vomiting (PONV) using a simplified risk score (*bold line*). The other two curves represent the overall predictive value (*thin line*) and the probability of vomiting accoring to the five score levels (*stepped line*) corresponding with the specificity. AUC = area under the curve.

Wuerzburg was 0.72 and thus slightly higher compared with the score from Oulu with an AUC of 0.66.

It could be demonstrated for both centers that the simplification of a score, by counting the number of the relevant risk factors, had a discriminating power similar to the score based on regression coefficients in the fitted logistic model. This is an important consideration if the score is to be applied to routine anesthetic practice. The only disadvantage of such a simple scoring system is that the likelihood of PONV cannot directly be derived from the number of risk factors. Thus, the simplified score was again processed in a logistic model so that the theoretical risks could be calculated. If these were related with the actual incidences in the other data set they revealed good calibration curves, irrespective of the center. Because the two studies were performed in two different countries, we expected some center effect because of differences in the patient population[4] or the manner of treatment that were not accounted for by the variables in our analysis. In addition, a marked center effect has been reported in the multicenter study of Cohen and colleagues[6]; however, their data may have been skewed because prophylactic antiemetic usage was not recorded. Because our study did not include the use of prophylactic antiemetics, we are inclined to conclude that a hypothesized center effect is negligible. The established patient-related factors seem to be most important even across centers from different countries and can explain the different incidence of PONV.

The four risk factors included in the final simple sum score were female gender, prior history of MS or PONV, nonsmoking, and the use of postoperative opioids. If no or only one risk factor is present the incidence of PONV may vary between about 10% and 21%, whereas if at least two risk factors are present it may rise to between 39% and 78%. As a consequence, a modification or change of the anesthetic technique might be considered if two or more risk factors are present. One approach would be prophylactic antiemetic treatment, because recent meta-analysis implies that the efficiency (in terms of the number needed to treat) may only be reasonable in high-risk patients.[21,22] Another approach would be to avoid volatile anesthetics entirely by using a total intravenous anesthetic technique, which has been shown to be associated with significantly less PONV.[23,24] Finally, this score might be useful for patient selection in antiemetic trials.

References

1. Watcha MF, White PF: Postoperative nausea and vomiting: Its etiology, treatment, and prevention. ANESTHESIOLOGY 1992; 77:162–84

2. Palazzo MG, Strunin L: Anaesthesia and emesis: I. Etiology. Can Anaesth Soc J 1984; 31:178–87

3. Camu F, Lauwers MH, Verbessem D: Incidence and aetiology of postoperative nausea and vomiting. Eur J Anaesthesiol 1992; 9(suppl 6):25–31

4. Palazzo M, Evans R: Logistic regression analysis of fixed patient factors for postoperative sickness: A model for risk assessment. Br J Anaesth 1993; 70:135–40

5. Haigh CG, Kaplan LA, Durham JM, Dupeyron JP, Harmer M, Kenny GN: Nausea and vomiting after gynaecological surgery: A meta-analysis of factors affecting their incidence. Br J Anaesth 1993; 71: 517–22

6. Cohen MM, Duncan PG, DeBoer DP, Tweed WA: The postoperative interview: Assessing risk factors for nausea and vomiting. Anesth Analg 1994; 78:7–16

7. Koivuranta M, Läärä E, Snåre L, Alahuhta S: A survey of postoperative nausea and vomiting. Anaesthesia 1997; 52:443–9

8. Apfel CC, Greim CA, Haubitz I, Goepfert C, Usadel J, Sefrin P, Roewer N: A risk score to predict the probability of postoperative vomiting in adults. Acta Anaesthesiol Scand 1998; 42:495–501

9. Korttila K: Can we predict who will vomit after surgery? (editorial). Acta Anaesthesiol Scand 1998; 42:493–4

10. Apfel CC, Greim CA, Haubitz I, Grundt D, Goepfert C, Sefrin P, Roewer N: The discriminating power of a risk score for postoperative vomiting in adults undergoing various types of surgery. Acta Anaesthesiol Scand 1998; 42:502–9

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021

11. Forrest JB, Beattie WS, Goldsmith CH: Risk factors for nausea and vomiting after general anaesthesia. Can J Anaesth 1990; 37:S90

12. Diamond GA: What price perfection? Calibration and discrimination of clinical prediction models. J Clin Epidemiol 1992; 45:85–9

13. Lerman J: Surgical and patient factors involved in postoperative nausea and vomiting. Br J Anaesth 1992; 69:24S–32S

14. Dent SJ, Ramachandra V, Stephen CR: Postoperative vomiting: Incidence, analysis and therapeutic measures in 3,000 patients. ANESTHESIOLOGY 1955; 16:564–72

15. Burtles R, Peckett BW: Postoperative vomiting: Some factors affecting its incidence. Br J Anaesth 1957; 29:114–23

16. Bonica JJ, Crepps W, Monk B: Postoperative nausea, retching and vomiting. ANESTHESIOLOGY 1958; 19:532–40

17. Smessaert A, Schehr CA, Artusio JF: Nausea and vomiting in the immediate postanesthetic period. JAMA 1959; 170:2072–6

18. Bellville, JW, Bross, IDJ, Howland, S: Postoperative nausea and vomiting IV: Factors related to postoperative nausea and vomiting. ANESTHESIOLOGY 1960; 21:186–93

19. Bellville, JW: Postanesthetic nausea and vomiting. ANESTHESIOLOGY 1961; 22:773–80

20. Chung F, Ritchie E, Su J: Postoperative pain in ambulatory surgery. Anesth Analg 1997; 85:808–16

21. Tramèr M, Moore A, McQuay H: Meta-analytic comparison of prophylactic antiemetic efficacy for postoperative nausea and vomiting: Propofol anaesthesia vs omitting nitrous oxide vs total i.v. anaesthesia with propofol. Br J Anaesth 1997; 78:256–9

22. Tramer M, Moore A, Reynolds DJ, McQuay H: A quantitative systematic review of ondansetron in treatment of established postoperative nausea and vomiting. BMJ 1997; 314:1088–92

23. Watcha MF, Simeon RM, White PF, Stevens JL: Effect of propofol on the incidence of postoperative vomiting after strabismus surgery in pediatric outpatients. ANESTHESIOLOGY 1991; 75:204–9

24. Gan TJ, Ginsberg B, Grant AP, Glass PS: Double-blind, randomized comparison of ondansetron and intraoperative propofol to prevent postoperative nausea and vomiting. ANESTHESIOLOGY 1996; 85: 1036–42

Downloaded from http://pubs.asahq.org/anesthesiology/article-pdf/91/3/693/397010/0000542-199909000-00022.pdf by guest on 27 December 2021