APACHE II, POSSUM, and ASA scores and the risk of perioperative complications in patients with colorectal disease

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OBJECTIVE: *This study was designed to assess the role of the ASA, POSSUM and APACHE II score systems for predicting the complications in patients undergoing surgery for colorectal diseases.*
METHODS: *We retrospectively analyzed 539 patients undergoing colorectal surgery between January 1996 and December 2006. The accuracy of ASA, POSSUM and APACHE II score systems for predicting perioperative complications has been analysed.*
RESULTS: *Total postoperative morbidity was 15%, overall perioperative mortality was 1.5%. APACHE II and POSSUM predicted with the same accuracy the perioperative complications (0.65 and 0.68, respectively), while ASA score system revealed a poorer predicting accuracy (0.56). POSSUM predicted death rate more accurately compared to the APACHE II classification (1.6% vs. 10.4%).*
CONCLUSIONS: *APACHE II and POSSUM score systems may be useful tools helping surgeons to identify patient groups at high risk for complications. The ASA classification resulted less accurate, probably because related to the anesthesiologist's knowledge.*

KEY WORDS: Colorectal surgery, Perioperative complications, Score systems.

Introduction

Mortality and morbidity rates are commonly used to compare quality within and across hospitals. A variety of score systems has been proposed to predict the outcome of patients undergoing surgical procedures, although with several limitations [1-6].
In the 1963 the American Society of Anesthesiologists (ASA) was created to evaluate and predict perioperative mortality and morbidity [2,7,8]. More recently, advanced statistical methods have allowed the ideation of new score systems like the APACHE [3] (Acute Physiology and Chronic Health Evaluation) score and POSSUM (Physiological and Operative Severity Score for Enumeration of Mortality and Morbidity) [4].
The APACHE index was created to predict mortality in intensive care units, but the experience with this classification induced to apply this score system to patients with severe trauma [9] and abdominal complications [10,11].
The POSSUM (1990) and the P-POSSUM (1998), developed by Copeland and colleagues for surgical patients, include physiological and operative parameters tested at the admission and operative variables (operation type, number of procedures, operative blood loss, peritoneal contamination, malignancy status and mode of surgery) [12,13].
The two scores (physiological and clinical) are collected into a computerized system that calculates the risk of morbidity and mortality [12,13]. Their ability to accurately predict morbidity and postoperative mortality after general surgery was proven in particular for patients with lung and colorectal cancer. Recently, POSSUM has been shown to be the most appropriate score in the evaluation of operative risk. [14]
The colorectal disease specific Cr-POSSUM has been developed over the last years for improving the prediction of mortality of the POSSUM score system [12,15]. However contrasting results [16-18] seem to question its presumed superiority for predicting postoperative complications.

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The aim of the study was to compare the accuracy of three general scoring systems, namely APACHE II, POSSUM and ASA, for the prediction of perioperative complications in patients undergoing surgical treatment for colorectal disease [19].

Patients and methods

A retrospective analysis has been performed on 539 consecutive patients undergoing colorectal surgery for malignant or benign colorectal disease between January 1996 and December 2006. Patients undergoing preoperative radio-chemotherapy, palliative treatment, and patients with inflammatory bowel disease and familial adenomatous polyposis were excluded. The remaining patients have been classified according to the APACHE II, P-POSSUM and ASA score systems.

The APACHE II classification [3,7,11] (a modified version of the original APACHE) includes 12 physiological parameters (temperature, mean arterial pressure, heart rate, respiratory rate, oxygenation, arterial pH, serum sodium, serum potassium, serum creatinine, hematocrit, white blood cell count and Glasgow Coma Scale score), age and severe chronic health problems (Table I). The physiological score is determined by the worst value collected during the first 24 hours after the admission to the intensive care units. In our study we applied the APACHE II score also to patients not admitted in the intensive care unit, based on the postoperative course of the first 24 hours.

The POSSUM [1-6] includes 12 parameters: age, cardiac status, pulse rate, systolic blood pressure, respiratory status, Glasgow Coma Scale score, and serum concentrations of urea, potassium and sodium, haemoglobin concentration, white blood cell count and results on electrocardiography [1-6] (Table II). The results of this data are combined with 6-factor operative score that adjust for the type of surgical procedure and includes the numbers and the type of surgical acts, volume of blood loss, peritoneal contamination, presence of malignancy or not and timing of the operations. In our study we have considered the three classes of surgical procedures as follows: minor (cutaneous colostomy or ileostomy), moderate (partial colonic resection) and major (total colectomy, anterior resection and abdominal perineal resection of the rectum). For both indexes, if an item was not evaluated or if the patient did not have any disease, the lowest score was assigned.

The ASA score system was assigned preoperatively by the anaesthesiologist during a preoperative outpatient consultation [7,8,11]. The POSSUM and APACHE II scores were calculated based on medical documents review [5,19-21].

The primary end-point of our study was to compare the accuracy of the three score systems for predicting perioperative morbidity.

For subgroups analysis, APACHE II and P-POSSUM scores were dichotomized using cut-off values previously decided. The cut-off were intended to define high-risk groups (a score value higher than 10 for APACHE II and higher than 24 for P-POSSUM).

Morbidity was defined as any complication within the first 30 days after operation. Local complications were those arising from the surgical wound without systemic effects. Systemic complications included: pneumonia, sepsis, respiratory failure, cerebral vascular accident, acute myocardial infarction, massive bleeding requiring blood transfusions or reoperation and operative death. Any death within 30 days of operation or within the same admission was classified as an operative death.

TABLE I – *Individual parameters required for calculation of the physiologic and operation severity in POSSUM.*

Physiological score
Age,
Cardiac signs,
Respiratory signs
ECG findings
Systolic blood pressure
Pulse rate
Hemoglobin
White cell count
Urea
Sodium
Potassium
Glasgow coma score
Operative severity score
Operation type
N. of procedures
Operative blood loss
Peritoneal contamination
Malignancy status
Mode of surgery

TABLE II – *List of individual parameters required for calculation of the physiologic and operation severity scores in APACHE II.*

Physiological variable
Temperature, °C
Mean arterial blood pressure, mmHg
Heart rate
Respiratory rate
Oxygenation (FIOÇ <0.5 or ≥0.5)
Arterial pH
Serum sodium, mEqL
Serum potassium, mEqL
Serum creatinine, mg/dL
Hematocrit, %
White blood cell count, x10^3/ÌL
Glasgow Coma Scale score
Age
Chronic organ insufficiency, immune-compromised

Statistical analysis

Chi-square, or Fisher's exact test when appropriate, was used for comparison of categorical variables. One-way analysis of variance (ANOVA) was applied for comparison of continuous variables. The receiver operating characteristic (ROC) curves were designed to identify the score values for ASA, POSSUM and APACHE II that provided the best prediction of postoperative morbidity and mortality [22,23]. The level for statistical significance was set at $p<0.05$ and confidence intervals were determined at the 95% level. All the analyses were performed using statistical software (Stata for Windows, Stata Corporation; College Station, Texas, USA).

Results

The mean age of patients examined was 65.7 years (median 67, range: 25-94 years). The distribution of the surgical procedures is illustrated in Table III. The surgical procedures performed for neoplastic disease were 374 (74%) and for diverticular disease 165 (26%). The mean length of stay was 10.9 days (range: 5-91 days).

The overall perioperative mortality was 1.5% (5 out of 539 patients: 3 due to sepsis and 2 as a consequence of pulmonary infections). The postoperative morbidity was 15% (83 out of 539 patients: 49 developed systemic and 34 local complications) (Table IV).

The mean APACHE II score was 7.0 in uncomplicated patients and 8.7 in patients with perioperative complications. The mean APACHE II predicted death rate was 10.4%.

The mean POSSUM score was 24 in uncomplicated patients and 26 in patients with perioperative complications. The mean POSSUM predicted death rate was 1.6%.

There was a statistically significant difference between the average APACHE II and POSSUM score values in patients with and without perioperative complications ($P<0.001$ for both, ANOVA) (Table V)

The postoperative morbidity was more frequent among patients with an APACHE II higher than 10 (5.5%) compared with patients with a score value of 10 or lower (1.9%) ($p=0.052$, chi-squared test), and among patients with P-POSSUM score higher than 24 (3,5%) compared with patients with a score of 24 or lower (0.8%) ($p=0.04$, chi-squared test).

TABLE III – *Type of surgery.*

Type of Surgery	N. Patients (%)
Colonic Resection	406 (75%)
Rectal Resection	72 (13%)
Total Colectomy	27 (5.5%)
Colostomy Ileostomy	34 (6.5%)

TABLE IV – *Frequency of postoperative complications.*

Complications	N.
None	456
Infection or wound dehiscence	29
Bowel obstruction	12
Pulmonary failure	9
Urinary Infection	8
Intestinal bleeding	5
Fever > 3 days	13
Cardiovascular failure	7

TABLE V – *Mean scores values of APACHE II and POSSUM according to the type of complications.*

	Complications		
Variable	None	Local	Systemic
APACHE II	6.64 (3.53)	8.36 (4.15)	10.22 (4.75)
POSSUM	26.12 (4.82)	28.83 (5.64)	30.33 (5.19)

The POSSUM index had an accuracy (0.68) for predicting perioperative complications significantly higher than ASA classification (0.56; $p=0.002$). The APACHE II score also showed a significant higher accuracy (0.65) than ASA classification ($P=0.04$). No significant difference between the areas under the ROC curve for POSSUM and APACHE II was found ($P=0.23$) (Figure 1).

Discussion

This study showed that APACHE II and POSSUM predict with almost the same accuracy the perioperative complications of the patients undergoing surgery for colorectal disease, while the ASA classification is less accurate. POSSUM showed a better predicted death rate compared to the APACHE II classification.

Recent studies indicated that APACHE II and POSSUM are the most accurate score systems in predicting perioperative complications in patients undergoing surgical treatment [24-27]. The POSSUM system is considered easy to apply in clinical practice, since it includes parameters easy to collect even in emergency. Furthermore, POSSUM analyzes both the physiological conditions of the patients and the complexity of the surgical procedure that may influence the postoperative outcome [1-11]. Several authors [2-6,12-14,19,20] emphasize that POSSUM may overestimate morbidity and mortality rates after emergency colorectal surgery, especially in low-risk patients.

The disease-specific Cr-POSSUM has been shown to have a higher accuracy than POSSUM and P- POSSUM in predicting perioperative mortality [12,15]. However, some studies showed contrasting results reporting no difference

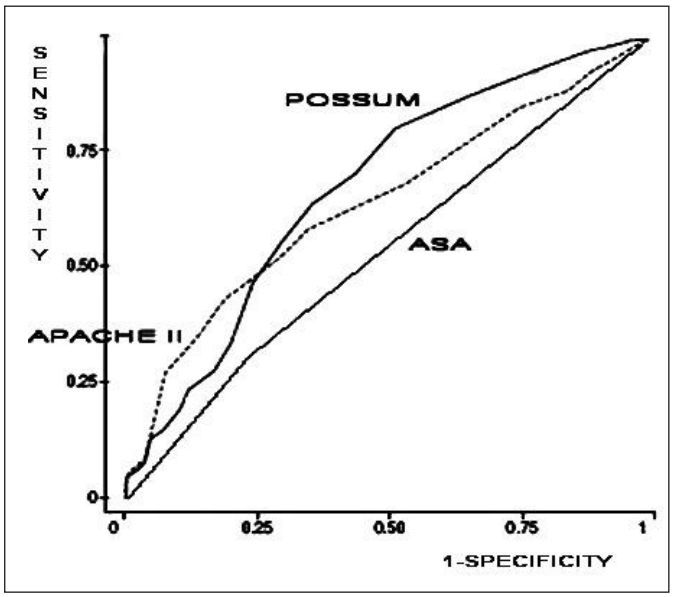

Fig. 1: ROC curve for ASA, APACHE II and POSSUM score system.

among POSSUM, P-POSSUM and Cr-POSSUM in predicting perioperative complications as well as mortality [16,17].

For these reasons, our use of POSSUM is well justified, considering also its easier applicability in daily clinical practice compared to Cr-POSSUM [18].

The APACHE II classification is considered flexible and able to predict different outcomes between elective and emergency surgery or between benign and malignant diseases. However, its application is limited in the daily clinical practice because it requires too many parameters that in emergency conditions may be difficult to collect. In addition, APACHE II classification do not include the nutritional state of the patient or the presence of important comorbidities (cardiovascular diseases or electrocardiographic findings) which may have an important effect on the outcome, and it does not consider the type of surgical procedures which may potentially increase the operative risk and the clinical outcome [2-5,11].

The ASA classification is the most used system, however its application in the daily clinical practice is subject to large variation among clinicians [10,24-27].

Our results confirm that the three scoring systems analyzed are not completely satisfactory for identifying patient groups at high risk for complications, although POSSUM showed the highest accuracy. The ASA classification resulted the least accurate, probably because related to the anesthesiologist's knowledge. The development of new classifications systems is warranted.

Riassunto

Lo scopo del presente studio è di analizzare l'accuratezza di tre score systems, ASA, APACHE II e POSSUM, nel predire il rischio di complicanze perioperatorie in pazienti sottoposti a chirurgia colo-rettale.

È stata condotta un'analisi retrospettiva su 539 pazienti sottoposti a chirurgia colo-rettale per patologie maligne e benigne tra gennaio 1996 e dicembre 2006, presso la 1ª Divisione di Chirurgia Generale - Cattedra di Chirurgia Generale dell'Università degli Studi di Brescia. I pazienti inclusi nello studio sono stati classificati utilizzando i criteri precisati dai tre score systems scelti, APACHE II, POSSUM ed ASA.

La morbidità postoperatoria è risultata pari al 15% (83 pazienti hanno sviluppato complicanze: 49 sistemiche e 34 locali). La mortalità perioperatoria è risultata essere dell'1.5% (5 pazienti deceduti).

APACHE II e POSSUM hanno mostrato la stessa accuratezza nel predire le complicanze postoperatorie (0.65 e 0.68, rispettivamente), mentre la classificazione ASA ha mostrato un'accuratezza predittiva inferiore (0.56). POSSUM è risultato in grado di predire con maggior precisione il rischio di mortalità perioperatoria rispetto ad APACHE II (predicted death rate 1.6% vs 10.4%).

APACHE II e POSSUM possono rappresentare strumenti utili al chirurgo per identificare pazienti ad alto rischio di complicanze postoperatorie. La classificazione ASA è risultata meno accurata probabilmente poiché influenzata dall'esperienza e dal giudizio dell'anestesista.

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