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Preoperative risk assessment in elective general surgery

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Despite improved surgical techniques there is still a risk of mortality in elective general surgery. In a prospective study preoperative data from 3250 patients were collected and compared with postoperative systemic complications, using univariate χ^2 analysis. Highly significant ($P < 0{\cdot}00001$) variables were subjected to stepwise logistic regression analysis. The severity of operative procedure, higher American Society of Anesthesiologists (ASA) grade, symptoms of respiratory disease and malignancy were found to be significant risk factors predicting postoperative morbidity ($P < 0{\cdot}05$). Using these four variables, a simple preoperative risk scoring system has been defined. Class A (up to 5 points) was defined as a low-risk group (systemic complication rate 5·0 per cent), class B (5–7 points) was intermediate risk (systemic complication rate 17·9 per cent) and class C (8–10 points) was high risk (systemic complication rate 33·3 per cent). Patients at high risk for perioperative and postoperative complications are more likely to be identified by this analysis than by using the ASA classification alone.

Despite improved surgical technique and intensive medical care, elective procedures, including general surgery, still carry a minimal risk of mortality[1,2]. Various attempts have been made to predict the morbidity of operative procedures, with special focus on a predefined group of patients at a presumed high risk[2–5]. In addition several techniques for preoperative risk assessment have been developed, with regard to pulmonary, cardiac or other complications[6–8]. No simple bedside risk scoring system for any perioperative or postoperative complication, including individual patient data as well as weighting details of the planned elective operation, has yet emerged. The present study was initiated with the aim of defining significant risk factors that affect the postoperative outcome in elective general surgery.

Patients and methods

Study design

In 1988 a prospective study was commenced to evaluate risk factors in elective general surgery[9]. Patients were eligible for the study if undergoing an elective procedure under general or spinal anaesthesia. Only the first operative procedure during the same hospital stay was considered. A patient who was operated on more than once during the same hospital stay was counted as one single case, and the preoperative study data were documented only once, before the first intervention. Patients re-entering the hospital for a second operation after a variable time were documented as new cases. The study end-points were the date of hospital discharge (no time limit) or of death in hospital. Patients eligible for the study were examined the day before operation. The variables listed in *Table 1* were collected using a bedside data sheet. Data collected before operation were correlated with postoperative systemic complications, including pulmonary, cardiac, septic or thromboembolic events, urinary tract infection and other complications (*Table 2*).

Patient characteristics

From 1 January 1988 to 31 December 1992, 3250 patients were studied (1750 men and 1500 women of mean(s.d.) age 52(16·8) years). Some 2994 patients (93·2 per cent) drank 20 g alcohol or less each day and 217 (6·7 per cent) drank more than 20 g alcohol daily (data missing from 39 patients). Some 1940 (60·6 per cent) were non-smokers, 1143 (35·7 per cent) were smokers and 119 (3·7 per cent) had a former history of tobacco consumption (data missing from 47 patients). In all, 125 patients (3·9 per cent) were diabetic (114 diabetes mellitus type II and 11

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Table 1 Preoperative study data

Patient history
Sex
Age
Consumption of alcohol (g ethyl alcohol per day)
Consumption of nicotin (no. of packs per year)
Diabetes mellitus (type I, type II, impaired glucose tolerance)
Symptoms of cardiovascular disease (dyspnoea, angina pectoris, intermittent claudication, myocardial infarction)
Symptoms of respiratory disease (cough, sputum, haemoptysis, etc.)
Symptoms of gastrointestinal disease (constipation, diarrhoea, vomiting, haematemesis)
Symptoms of urological disease (nycturia, dysuria)
Complications following previous surgery
Physical examination
Body weight : height ratio
Lung and heart examination (auscultation, percussion)
Neck vein congestion
Abdominal examination (i.e. liver and spleen)
Technical examinations
Radiography of the chest*
Electrocardiography*
Lung function tests*† (vital capacity, forced expiratory volume in 1 s)
Haematology (haemoglobin, haematocrit, white cell count)
Blood chemistry (potassium, serum glutamic–oxaloacetic transaminase, creatinine, quick test)
ASA classification‡
Operative details
Group of planned operative procedure (*Table 3*)
Assumed malignancy of the disease (including the result of preoperative histopathological examinations)

*Not routinely performed in patients aged under 45 years and undergoing minor operation, excluding entry to the abdominal or thoracic cavity. †Low number of registered cases did not allow statistical analysis. ‡American Society of Anesthesiologists (ASA) grade was not recorded routinely during the first year of the study

Table 2 Postoperative systemic complications

Complication	No. of patients
Pneumonia	77 (23·9)
Atelectasis	48 (14·9)
Cardiac events	46 (14·3)
Septic complications	36 (11·2)
Thromboembolism	12 (3·7)
Other*	103 (32·0)
Total	322† (100)

Values in parentheses are percentages. *Includes urogenital infection; †15 missing values

diabetes mellitus type I) (data missing from 17 patients). Ninety patients (2·8 per cent) had a history of myocardial infarction (data missing from five patients) and 508 (19·9 per cent) of 2554 patients had symptoms of respiratory disease (chronic bronchitis, asthma bronchiale). Mean(s.d.) excess weight was 7·7(12) kg for men and 11·0(13·2) kg for women, based on ideal body-weight (body length (cm) − 100) − ((body length (cm) − 100) × 10 per cent (men) or × 15 per cent (women)).

Cardiopulmonary examination revealed arrhythmias in 118 of 3239 patients (especially atrial fibrillation and supraventricular premature beats); 355 of 3245 had pathological heart sounds; and 286 of 2570 patients had abnormal lung sounds. Some 2236 patients underwent preoperative chest radiography, with a pathological finding in 651 cases (29·1 per cent); 2655 underwent electrocardiography, which was abnormal in 514 cases (19·4 per cent).

With regard to the new classification of physical status of the American Society of Anesthesiologists (ASA)[10], before operation 43·1 per cent (1088 of 2524 patients) were classified as ASA grade I, 41·4 per cent (1046) as ASA grade II, 13·7 per cent (345) as ASA grade III, 1·8 per cent (45) as ASA grade IV and none as ASA grade V.

Planned procedures were divided in four groups, each of which included operations of comparable status (data missing from 24 patients): group 1, operations excluding entry to the abdominal or thoracic cavity; group 2, minor abdominal interventions (including minimally invasive procedures); group 3, thoracic surgery; group 4, major upper abdominal surgery and retroperitoneal interventions.

Statistical analysis

All information was stored in a computer database. Each preoperative variable (*Table 1*) was correlated first with systemic postoperative complications by univariate χ^2 analysis. Factors with a highly significant result in univariate analysis ($P < 0{\cdot}00001$) were then subjected to stepwise logistic regression analysis with the standard program of the Statistical Package for the Social Sciences (1990, version 4.0) (SPSS, Chicago, Illinois, USA).

Results

Systemic complications are shown in *Table 3* and occurred in 10·4 per cent (337 patients) during the postoperative course. Some 42 patients died during the hospital stay (1·3 per cent); 23 were operated on for malignant disease: 14 as a palliative procedure and nine with curative intent.

By univariate analysis, the following parameters had a highly significant ($P < 0{\cdot}00001$) association with postoperative systemic complications: age, respiratory symptoms, abnormal lung sounds, pathological chest radiograph, low haematocrit (less than 40 per cent for men and less than 37 per cent for women), increasing ASA grade, severity of operative procedure (groups 1–4; *Table 3*) and finally malignant *versus* benign disease (*Table 4*). These parameters were analysed separately by stepwise logistic regression analysis. Finally, only four variables had a significant association with systemic postoperative complications with decreasing significance: severity of operative procedure, increasing ASA grade, symptoms of respiratory disease and malignancy.

Based on these findings a multifactorial risk scoring system was created (*Table 5*). The four groups of operative procedure are represented by a maximum of 4 points as well as the four ASA grades. Respiratory symptoms and malignant character of the disease are each counted as 1 point. Thus a patient with ASA grade I (1

Table 3 Postoperative study data

Operative procedure*	No. of patients	No. of systemic complications
Group 1	1317	55 (4·2)
Group 2	1194	146 (12·2)
Group 3	459	76 (16·6)
Group 4	256	60 (23·4)
Total†	3226	337 (10·4)

Values in parentheses are percentages. *Group 1, operations excluding entry to the abdominal or thoracic cavity; group 2, minor abdominal interventions (including minimal invasive surgery); group 3, thoracic surgery; group 4, major upper abdominal surgery and retroperitoneal interventions. †Data missing from 24 patients

Table 4 Results of univariate analysis for risk of general complications

Variable*	χ^2	d.f.	P
Age	38·24	4	< 0·00001
Symptoms of respiratory disease	38·49	1	< 0·00001
Abnormal lung auscultation	30·65	1	< 0·00001
Abnormal chest radiograph	26·04	1	< 0·00001
Low haematocrit (men < 40 per cent, women < 37 per cent)	30·55	1	< 0·00001
Increasing ASA grade	97·09	3	< 0·00001
Severity of operative procedure (groups 1–4)	129·21	6	< 0·00001
Malignant disease	69·31	1	< 0·00001
Cigarette consumption (packs per year)	22·81	3	0·00004
Alcohol consumption (> 20 g per day)	19·87	2	0·00005
Serum glutamic–oxaloacetic transaminase (> 60 units l^{-1})	15·61	1	0·00008
Quick test (< 0·70)	15·57	1	0·00008
Pathological lung percussion	14·37	1	0·00015
Leucocyte count (> $9{\cdot}6 \times 10^6$)	16·78	2	0·00023
Symptoms of gastrointestinal disease	29·13	8	0·00030
Neck vein congestion	16·17	2	0·00031

*Variables with a P value of < 0·001 in χ^2 analysis. ASA, American Society of Anesthesiologists

Table 5 Results of multiple logistic regression analysis: risk scoring system

Variable*	Correlation coefficient (r)	P	Risk score (range of points)
Group of operative procedure (1–4)†	0·1667	< 0·00001	1–4
ASA classification (I–IV)‡	0·1066	< 0·00001	1–4
Respiratory symptoms (no = 0 points, yes = 1 point)	0·0693	0·002	0–1
Pathology of the disease (benign = 0 points, malignant = 1 point)	0·0541	0·0101	0–1
Minimum possible			2
Maximum possible			10

*Analysis of variables with a P value of < 0·00001 in χ^2 analysis. †Group 1, operations excluding entry to the abdominal or thoracic cavity; group 2, minor abdominal interventions (including minimal invasive surgery); group 3, thoracic surgery; group 4, major upper abdominal surgery and retroperitoneal interventions. ‡Patients with American Society of Anesthesiologists (ASA) grade V are unable to undergo elective surgery

Table 6 Retrospective application of the risk scoring system in comparison with the American Society of Anesthesiologists classification*

Score	No. of patients	Systemic complications
Risk class†		
A	1532	76 (5·0)
B	853	153 (17·9)
C	102	34 (33·3)
Total‡	2487	263 (10·6)
ASA grade		
I	1087	57 (5·2)
II	1046	121 (11·6)
III	343	77 (22·4)
IV	45	12 (26·7)
Total	2521	267 (10·6)

Values in parentheses are percentages. *Includes data from 1989 to 1992 (American Society of Anesthesiologists (ASA) classification not routinely registered in 1988). †Risk class A, up to 5 points; B, 5–7 points; C, 8–10 points. ‡Thirty-four missing values

point), without symptoms of respiratory disease (0 points), undergoing haemorrhoidectomy (1 point) for benign disease (0 points) would be classified with a minimum of 2 points, whereas a patient with chronic bronchitis (1 point) in ASA grade IV (4 points), undergoing oesophagectomy (4 points) for cancer (1 point) is classified with a maximum of 10 points.

Some 2487 valid patient data (an additional 34 missing values) could be scored retrospectively with this new system, as ASA grade was not collected in 1988, the first year of the study. Patients with a total maximum of 4 points could be classified as a low-risk group with a systemic complication rate of 5·0 per cent (76 of 1532 patients); 5–7 points represented an intermediate risk group with 17·9 per cent having systemic complications (in 153 of 853 patients); and those with more than 7 points had a high risk of 33·3 per cent (34 of 102) of developing systemic postoperative complications. According to these risk groups, three risk classes can be defined: class A, patients at low risk with a maximum of 4 points; class B, patients at intermediate risk with 5–7 points; and class C, patients at high risk with 8–10 points.

The rate and frequency of systemic complications in the various ASA grades were also examined: ASA grade I, 5·2 per cent (57 of 1087 patients) of systemic complications; ASA II, 11·6 per cent (121 of 1046); ASA III, 22·4 per cent (77 of 343); ASA IV, 12 of 45 patients (*Table 6*).

Discussion

One of the main preconditions for eliminating mortality from elective surgery consists of a systematic prospective analysis of patient data large enough to perform multivariate analysis of possible risk factors associated with life-threatening complications and leading to a fatal outcome.

In the present study four significant risk factors for systemic perioperative complications after elective general surgery could be identified. It is well known that the operative procedure *per se* is one of the most important factors influencing the postoperative outcome[2,6]. The ASA classification and the symptoms of respiratory disease focus on the patient and the systemic disease[6,10,11]. The presence of pulmonary disease becomes even more important in the case of emergency procedures for gastrointestinal perforation[12]. Previous reports have shown that simple clinical information provides as much data about the patient's risk of developing postoperative pneumonia as lung function tests[7]. Finally, the disease is measured by its benign or malignant character. Several studies of risk assessment have shown the value of including histological information in scoring systems[13,14].

In the past, several scoring systems have been suggested to estimate individual operative risk[4,8,13,15]. Only a few focus on systemic perioperative and postoperative complications without any limitations[10,14]. The ASA classification is the only system that is readily usable at the bedside. This scoring system has the disadvantage that only patient-related data are considered. This paper suggests a risk scoring system based on the four above-mentioned variables: severity of operative procedure, ASA classification, respiratory symptoms and disease pathology. These variables include patient data as well as data describing the planned operative procedure and the disease itself. In order to avoid complicating the scoring system, the different values of the correlation coefficients were not taken fully into account (*Table 5*). The operation and ASA classification have been weighted equally, despite a moderate difference in the correlation coefficient of 0·0601. Nevertheless, we are able to define a high-risk group of patients with more general complications (+24·7 per cent) than in ASA grade IV. At the same time, this new high-risk group includes an increased (+127·8 per cent) number of patients, compared with ASA grade IV.

The results of this analysis indicate that the risk of elective general surgery can readily be predicted using the proposed risk scoring system. Patients at high risk of perioperative and postoperative systemic complications are more likely to be defined than with the ASA classification alone.

References

1 Proye C, Camp D, Triboulet JP, Carnaille B, Verin P, Sautier M. Postoperative death in a French surgical professional unit. Year 1985: 1409 patients operated. 45 post-operative deaths. *J Chir* 1988; **125**: 255–9.

2 Sitzmann JV, Greene PS. Perioperative predicators of morbidity following hepatic resection for neoplasm. *Ann Surg* 1994; **219**: 13–17.

3 Mäkelä JT, Kellosalo J, Laitinen SO, Kairaluoma MI. Morbidity and mortality after abdominal operations for cancer. *Hepatogastroenterology* 1992; **39**: 420–3.

4 Ondrula DP, Nelson RL, Prasad ML, Coyle BW, Abcarian H. Multifactorial index of preoperative risk factors in colon resections. *Dis Colon Rectum* 1992; **35**: 117–22.

5 Agarwal N, Leighton L, Mandile MA, Cayten CG. Outcomes of surgery for colorectal cancer in patients age 80 years and older. *Am J Gastroenterol* 1990; **85**: 1096–101.

6 Garibaldi RA, Britt MR, Coleman ML, Reading JC, Pace NL. Risk factors for postoperative pneumonia. *Am J Med* 1981; **70**: 677–80.

7 Williams-Russo P, Charlson ME, MacKenzie CR, Gold JP, Shires GT. Predicting postoperative pulmonary complications. Is it a real problem? *Arch Intern Med* 1992; **152**: 1209–13.

8 Goldman L, Caldera DL, Nussbaum SR *et al.* Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med* 1977; **297**: 845–50.

9 Largiadèr F, Buchmann P, Candinas D, Metzger U, Uhlschmid G. A prospective study of risk factors in elective general surgery. *Theoretical Surgery* 1991; **6**: 19–24.

10 American Society of Anesthesiologists. New classification of physical status. *Anesthesiology* 1963; **24**: 111.

11 Menke H, John KD, Klein A, Lorenz W, Junginger T. Präoperative Risikoeinschätzung mit der ASA-Klassifikation. *Chirurg* 1992; **63**: 1029–34.

12 Rypins EB, Khan F, Collins-Irby D, Sarfeh IJ, Ashurst JT, Stemmer EA. Computer-derived equations for predicting survival postoperatively. Their usefulness and limitations. *Arch Surg* 1988; **123**: 354–7.

13 Gagner M. Value of peroperative physiologic assessment in outcome of patients undergoing major surgical procedures. *Surg Clin North Am* 1991; **71**: 1141–50.

14 Copeland GP, Jones D, Walters M. POSSUM: a scoring system for surgical audit. *Br J Surg* 1991; **78**: 355–60.

15 Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. *Crit Care Med* 1985; **13**: 818–29.