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Charlson index and the surgical risk scale in the analysis of surgical mortality

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A B S T R A C T

Introduction: There is controversy over how to assess surgical mortality risks after different operations. The purpose of this study was to assess the surgical factors that influenced surgical mortality and the ability of the Charlson Index and The Surgical Risk Scale (SRS) to determine low risk patients.

Material and methods: All patients who died during the period 2004-2007 were included. The score of both indices (Charlson and SRS) were recorded. A score of "0" for the Charlson Index and «8» for the SRS were chosen as the cut-off point between a low and high probability of death. Three risk groups were established: Low when the Charlson was =0 and SRS was <8; Intermediate when the Charlson was >0 and the SRS <8 or Charlson=0 and SRS≥8; and high when the Charlson was >0 and the SRS≥8. The risks factors before, during and after surgery were compared between the groups.

Results: A total of 72,771 patients were surgically intervened, of which 7011 were urgent. One in every 1455 patients died during surgery and 1 in every 112 died during their hospital stay. Thirteen (2%) patients who died belonged to the low risk group, 199 (30.7%) to the intermediate risk group, and 434 (67.2%) to the high risk group. Heart disease was associated with the high risk group. The urgency of the operation was a determining factor associated with surgical complexity. Re-intervention and sepsis predominated as a cause of death in the low risk group, and in the rest of the groups a cardiac cause was the predominant factor.

Conclusions: The combination of the Charlson Index and SRS detected those patients with a low risk of death, thus making it a useful tool to audit surgical results.

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Valor de los índices de Charlson y la escala de riesgo quirúrgico en el análisis de la mortalidad operatoria

Palabras clave:
Palabras clave:
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Pacientes quirúrgicos
Índices de riesgo

RESUMEN

Introducción: Existe controversia sobre cómo valorar los riesgos de mortalidad quirúrgica tras distintas intervenciones. El objetivo de este estudio es valorar los factores operatorios que influyeron en la mortalidad quirúrgica y la capacidad de los índices de Charlson y la Escala de Riesgo Quirúrgico (SRS) en determinar los pacientes de bajo riesgo.

Material y métodos: Se incluyeron todos los pacientes que fallecieron en el periodo 2004-2007. Se recogió la puntuación de ambos índices. Se escogió el punto de división entre baja y alta probabilidad de muerte una puntuación de «0» para el índice de Charlson y de «8» para el SRS. Se han establecido tres grupos de riesgo: bajo, cuando el Charlson fue = 0 y el SRS fue < 8. Intermedio, cuando el Charlson fue > 0 y SRS < 8 o Charlson = 0 y SRS ≥ 8. Alto, cuando el Charlson fue > 0 y el SRS ≥ 8. Se han comparado los factores de riesgo pre-intra-postoperatorios entre los grupos.

Resultados: Se intervinieron 72.771 pacientes, de los cuales 7.011 lo fueron en régimen de urgencia. Fallecieron uno de cada 1.455 pacientes en el intraoperatorio y 1 de cada 112 pacientes durante su ingreso hospitalario. Trece (2%) pacientes fallecidos pertenecían al grupo bajo riesgo, 199 (30,7%) al de riesgo intermedio y 434 (67,2%) al de riesgo alto. Se asoció enfermedad cardiaca al grupo de alto riesgo. La urgencia fue un factor determinante que se asoció a la complejidad quirúrgica. En el grupo de bajo riesgo predominó la reintervención y la sepsis como causa de muerte; para el resto de los grupos predominó la causa cardiaca.

Conclusiones: La combinación del índice de Charlson y el SRS detectó aquellos pacientes de bajo riesgo de muerte siendo una herramienta útil para auditar los resultados operatorios.

Introduction

In the evaluation of surgical risk, ratings applied to different surgical patient models have been established. The Charlson index, described in 1987[1] defines different clinical conditions to predict mortality at one year.[1] There are 19 predefined comorbidities assigned a value (Table 1). Several studies involving over 30 000 patients have validated the Charlson index.[2,3] The Surgical Risk Scale (SRS) calculated for each type of surgery is based on three factors (Table 2): the results of the Confidential Enquiry Into Perioperative Deaths (CEPOD), the value assigned in the American Society of Anesthesiologists (ASA) risk classification and the extent of surgery according to the classification of BUPA (British United Provident Association). To prepare the SRS, data were collected from 3144 patients with a mortality rate during hospital stay of 0.4%. The scale was validated prospectively on 2780 additional patients and a cut-off value of SRS>8 was set, after which mortality increased significantly.[4]

Table 1 – Charlson Index conditions and values

Comorbidity	Value
Myocardial infarction	1
Congestive heart failure	1
Peripheral vascular disease	1
Cerebrovascular disease	1
Dementia	1
Chronic lung disease	1
Connective tissue disease	1
Peptic ulcer	1
Benign liver disease	1
Diabetes	1
Hemiplegia	2
Moderate or severe renal failure	2
Diabetes with organic affection	2
Cancer	2
Leukaemia	2
Lymphoma	2
Moderate or severe liver disease	3
Metastasis	6
AIDS	6

Both risk indices (Charlson and SRS) were applied in all surgical patients who died in our hospital during the 2004-2007 period, and different mortality risk groups were determined according to the values obtained. The aim of our study was to analyse the factors, before, during and after operations, which influenced mortality in low, medium and high risk groups. A secondary objective was to assess the ability of both indices to identify patients at low risk of surgical mortality.

Material and method

After obtaining approval from the hospital's ethics committee, a cross-sectional, retrospective study was conducted. Surgical information was obtained from hospital discharge reports, as well as the patient's history. All patients who underwent

Table 2 – Surgical Risk Scale conditions and values

	Description	Value
CEPOD		
Elective	Non urgent (varicose veins, hernia)	1
Scheduled	Preferential (colon neoplasia, AAA)	2
Urgent	Urgent >24 h (intestinal obstruction)	3
Emergency	Urgent, immediate (AAA rupture)	4
BUPA		
Minor	Sebaceous cyst, skin lesions, endoscopy	1
Intermediate	Unilateral varicose veins, unilateral hernia, colonoscopy	2
Major	Appendectomy, open cholecystectomy	3
Major plus	Gastrectomy, colectomy, laparoscopic cholecystectomy	4
Complex Major	Carotid endarterectomy, AAA, low anterior resection, oesophagectomy	5
ASA		
I	Without systemic disease	1
II	Mild systemic disease	2
III	Systemic disease affecting activity	3
IV	Serious illness but not moribund	4
V	Moribund	5

ASA indicates American Society of Anesthesiologists; BUPA, British United Provident Association; CEPOD, Confidential Enquiry into Perioperative Deaths.

surgery during 2004-2007, where the final outcome of death during hospitalisation was related to the surgical process, were analysed. Different clinical and anaesthetic variables were grouped according to three stages (pre-, intra- and post-operative). The type of surgery was defined according to the area and complexity: (1) extensive resection of organs (eg. pneumonectomy) and cardiovascular surgery; (2) partial resection of organs (eg, lobectomy); (3) minor resections; and (4) extracavitary and minimally invasive surgery. Six types of probable causes of death were considered: (1) bleeding; (2) cardiac; (3) respiratory; (4) neurological; (5) sepsis, including suture dehiscence; (6) cancer, when the cause of death was related to the extension of the oncological process.

The Charlson index value was obtained from secondary diagnoses at the time of admission. Each patient was assigned a SRS value according to the study variables contained in the discharge report, and this information was recorded directly in the patient's medical history.

The cut-off point between low and high probability of surgical mortality that determined the best relationship between sensitivity and specificity in both indices was a value of 0 in the Charlson index and 8 in the SRS.[4-6] This cut-off point established three risk groups:

- Low Risk (LR), with both indices low: Charlson =0 and SRS<8
- Intermediate Risk (IR), with one of the indices providing a low risk of death: Charlson >0 and SRS<8 or Charlson =0 and SRS≥8
- High Risk (HR), with both the Charlson index >0 and SRS=8

The data were statistically analysed using SPSS software, version 12. The results of the descriptive statistics were expressed as percentages, means and standard deviations. To study the possible relationship between qualitative variables, the chi-square test (or Fisher's exact test, where necessary) were used. To study the relationship between quantitative variables, the student t-test and ANOVA were used. In all cases, *P* values <.05 were considered significant.

Results

During the study period (2004-2007) a total of 72 771 patients underwent surgery in our hospital, of whom 19 510 were outpatients, where there were no deaths. Of the 53 261 patients who were admitted to hospital, 45 250 underwent elective surgery, with 189 patients dying during hospitalisation (0.4% mortality), and 8011 underwent emergency surgery, of whom 457 died (5.7% mortality). Of the 646 patients who died during their stay in hospital, 50 of them died during the surgical procedure and 596 during the postoperative phase. There were no deaths directly related to anaesthesia nor have we recorded incidents caused by equipment failures involved in the perioperative management of patients, so that all patients who died were included in the evaluation.

When applying the mortality prediction rates, the Charlson index and Surgical Risk Scale (SRS), to the 646 patients who died, it was observed that:

- 13 patients (2%) corresponded to the low risk group (LR)
- 199 patients (30.7%) corresponded to the intermediate risk group (IR)
- 434 patients (67.2%) corresponded to the high risk group (HR)

The Table 3 lists the characteristics (pre-, intra-, and post-operative) of different patient groups. There were

Table 3 – Characteristics —before, during and after— of patients with low (LR) intermediate (IR) and high (HR) mortality risk

Variable	LR	IR		HR
		Charlson=0+SRS≥8	Charlson>0+SRS<8	
Patients (n, %)	13 (2%)	48 (7.4%)	151 (23.3%)	434 (67.18%)
Preoperative stage				
Age(years)	69 (22)	69 (25)	72 (13)	73 (14)
Sex (males%)	39%	48%	66%	69%
Toxic habits	8%*	13%	42%	31%
COPD	0%	0%	12%	20%*
High blood pressure	15%	29%	48%	51%*
Heart attack	0%	0%	14%	21%*
Congestive heart failure	0%	0%	4%	16%*
Peripheral arterial disease	0%	0%	25%	24%*
Kidney diseases	0%	0%	16%	20%*
Liver/digestive diseases	0%	0%	25%	25%*
Neurological disorders	0%	0%	11%	11%*
Diabetes	0%	0%	26%	26%*
Diagnosed with neoplasia	0%	0%	54%	32%*
Number of AI	1.9 (1.1)**	1.4 (1.2)	3.8 (1.9)	3.9 (1.9)
Intraoperative stage				
Emergency intervention	77%	100%*	23%	84%
Type of surgery				
Type 1	0%	0%	0%	16%
Type 2	0%	8%	16%	18%
Type 3	15%	75%	32%	52%
Type 4 and 5	85%	17%	52%	14%
Type of anaesthesia				
General	80%	75%	77%	80%
Subarachnoid	0%	12%	8%	9%
Local	0%	8%	2%	2%
Sedation	20%	5%	13%	9%
Duration of intervention (hours)	2.1 (1.7)	1.8 (1.5)	2.5 (1.8)	2.7 (2.1)
Transfusion during operation	8%	15%	3%	6%
Intraoperative complications	23%	17%	5%	16%
Haemodynamic complications	23%	15%	4%	15%
Death	8%	6%	2%	10%
Postoperative stage				
Admission to critical care	67%	69%	50%	56%
Reintervention	42%*	29%	33%	29%
Infection	42%*	13%	17%	17%
Sepsis	58%*	18%	22%	31%
Cardiac problems and HDNM	67%	40%	51%	54%
Ischemic heart disease	0%	0%	3%	5%
Congestive heart failure	0%	7%	19%	14%
Respiratory complications	58%	44%	52%	51%
Kidney problems	25%	24%	24%	29%
Liver/digestive problems	0%	2%	5%	9%
Neurological problems	25%	24%	24%	29%
Cause of death				
Sepsis	54%*	15%	20%	21%
Respiratory	15%	29%	27%*	23%
Haemorrhagic shock	8%	8%	4%	8%
Cardiac and HDNM	8%*	38%	31%	35%
Neurological	15%	10%	11%	6%
Cancer	0%	0%	7%	7%

The quantitative data is shown as average (standard deviation) . AI: associated illnesses; COPD: chronic obstructive pulmonary disease; HDNM: haemodynamics; Type of surgery: see methods.
* P<.05 chi-square test
** P<.05 analysis of variance test (ANOVA)

no differences in age for the different risk groups. Males dominated the groups most at risk. The presence of comorbidity was higher in high and intermediate risk groups with a Charlson index >0. Emergency was an important factor associated with groups where surgical complexity was higher (HR and IR; SRS>8).

There were 43 intraoperative deaths (10%) in the HR group, 6 (3%) in the IR group and 1 (8%) in the LR group, which indicated that the extent of surgery associated with comorbidity determined the mortality in the operating room. Haemodynamic and respiratory complications occurred equally in all groups. Infection-sepsis and re-intervention predominated in the low risk group, with the majority cause of death from sepsis. By contrast, death from a cardiac-haemodynamic origin predominated in the other two groups. Regarding the influence of both indices in the intermediate risk group, no other differences in any of the variables studied (Table 3) were obtained, except for the presence of emergency surgery.

Discussion

In our study, intraoperative mortality was 1 per 1455 patients and was reported as 1 in 112 patients undergoing surgery, similar to other studies in the adult population.[7] No differences were found between the risk groups regarding age, so it was not a bias factor in comparing groups. The characteristics of the indices determined the associated pathology, less common in those groups with a Charlson index of 0. Toxic habits, respiratory and heart disease predominated in patients with complex surgery, with both as determinants of mortality associated with the high risk group, where the emergency factor also influenced mortality, especially intraoperatively.

Surprisingly, the duration of surgery and admission to the recovery unit were similar for all groups regardless of the extent of surgery, indicating that intraoperative complications were decisive. The low risk patient group (LR) had rates of reoperation, infection and sepsis significantly higher than other groups.

Several studies identify the Charlson index as valid for signalling mortality.[8-10] Although Poses et al[11] showed lower reliability on Charlson compared to Apache II for mortality. However, Apache requires clinical and laboratory data to be collected during 24 hours upon admission. It is also a prognostic index and does not predict risk a priori, therefore the Charlson index is more appropriate for risk adjustment in the health services.[6,12] The SRS is recognised in the literature as a surgical risk assessment index[4] and has been compared optimally with POSSUM.[13] Other measurement systems like the physiological severity ratio (POSSUM and P-POSSUM[14-16]) include preoperative, intraoperative and postoperative physiological factors, and are thus predictive and not determinant of risk, and in turn they overestimate mortality.[17] Another advantage of SRS is the simplicity and validity of the risk prediction.[18] Elixhauser[19] proposed the independent assessment of 30 chronic diseases on admission. This is the most comprehensive approach regarding the number of secondary diagnoses with respect to Charlson and the one used mostly for the risk adjustment of patient safety indicators. However, incorporating pathophysiological data could differentiate patients with compensated comorbidity from those without it. Pine et al[20] applied an incremental laboratory and clinical data model to the administrative model in three surgical procedures, and obtained a modest improvement in hospital mortality risk adjustment, but they used more resources to obtain the information.

In our study, the association of the Charlson index and the SRS clearly identified high risk patients, and identified a group of outlier patients, whose probability of death should be close to 0%, and which corresponded to 1 in 5590 patients anaesthetised and operated upon in our hospital over a period of four years. The factors differentiating this group of patients were surgical complications emphasised by a reoperation rate in 42% and septic complications in 58%.

Mortality after surgery can be assessed from the point of view of patient safety, Lagasse[21] defined human error as anaesthetic and surgical techniques being applied improperly, improper use of material or incorrect interpretation of the clinical assessment of the patient. This was mainly due to a limitation in understanding the scientific basis for proper practice. System error was defined as the inevitable adverse outcome usually excluded from adverse outcome analysis. The minimum basic data set extracted from hospital discharge records is a tool, with limitations,[22] which is valid for analysing surgical morbidity and mortality. Improving outcomes require causes to be known and redesign management strategies for patients at risk.[23,24]

The most relevant results in this study are those that combine both indices, Charlson and SRS, which found the patients at low risk of death. The simplicity of both indices and their availability prior to the intervention is a useful tool for conducting audits of surgical results. Finally, the main causes of surgical death were cardiac for patients at increased risk and septic for patients at lower risk.

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Conflicts of interests

The authors affirm that they have no conflicts of interests.

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