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Mortality risk factors in surgical patients in a tertiary hospital: a study of patient records in the period 2004–2006

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A B S T R A C T

Objective: To determine mortality risk factors in surgical patients.
Material and method: A cross-sectional study was carried out on all surgical patients who died while in hospital, over a period of 3 years (2004–2006). Pre, intra, and postoperative variables were analysed. Comparisons were made between patients operated on as emergencies and elective surgery patients. Multivariate analysis was performed on the pre, intra, and postoperative variables, using χ^2 of Pearson correlation with a confidence interval of 95%.
Results: Surgery was performed on a total of 38 815 patients, of which 6326 were emergency procedures and 32 489 as elective. There were 479 deaths registered: 36 occurred in the operating theatre and 443 died after the operation. Arterial hypertension, diabetes mellitus, and cancer were significant causes of death. Intraoperative complications were associated with mortality during the surgical procedure. Emergency surgery was an independent risk factor (mortality, 5.5% vs 0.4% for elective surgery). Sepsis, cardiac, and respiratory related deaths were the main risk factors for postoperative death.
Conclusions: Prevention and adequate treatment of perioperative risk factors should significantly reduce morbidity and mortality rates, mainly in those patient operated as emergencies.

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Factores de riesgo de mortalidad de los pacientes quirúrgicos en un hospital terciario: estudio del registro de pacientes en el periodo 2004–2006

Palabras clave:
Morbidity
Mortality
Surgical patients
Risk factors

R E S U M E N

Objetivo: Determinar los factores de riesgo de mortalidad de los pacientes quirúrgicos.
Material y métodos: Se incluyó a todos los pacientes operados que fallecieron en el curso del procedimiento peroperatorio en el periodo 2004–2006. Se realizó un estudio de corte transversal. Se analizaron variables preoperatorias, intraoperatorias y postoperatorias. Se han analizado los factores de riesgo de muerte en los pacientes intervenidos de urgencia y en los intervenidos electivamente. Se ha realizado un análisis multivariable correlacionando las diferentes variables mediante la prueba de la χ^2 de Pearson con un intervalo de confianza del 95%.
Resultados: Durante el periodo que abarca el estudio fueron intervenidos 38.815 pacientes con ingreso hospitalario: 6.326 de urgencia y 32.489 de forma electiva. Durante el ingreso hospitalario murió un total de 479 pacientes; 36 intraoperatoriamente y 443 tras la intervención quirúrgica. La hipertensión arterial, la diabetes mellitus y el diagnóstico de neoplasia tuvieron significación estadística con la muerte. Las complicaciones quirúrgicas resultaron significativas para los pacientes que fallecieron en el intraoperatorio. La cirugía de urgencia es un factor de riesgo independiente de mortalidad (5,5% de mortalidad en relación con el 0,4% para la cirugía electiva). Las complicaciones postoperatorias fueron los principales factores de riesgo de mortalidad, en especial la sepsis, los problemas cardíacos y los respiratorios.
Conclusiones: La prevención y el correcto tratamiento de todos los factores de riesgo preoperatorios, intraoperatorios y postoperatorios se presume disminuirían de forma significativa los índices de mortalidad y morbilidad de los pacientes intervenidos quirúrgicamente, en especial en aquellos intervenidos de urgencia.

Introduction

The development of different surgical and anaesthetic techniques over the last decade has resulted in an increase in the number of surgical interventions as well as in their complexity.[1] The surgical patients have gained greater importance among admitted patients.[2] In 1995, Barie[3] discovered that operations were the third highest cause for admissions into intensive care units, with a 19% mortality rate; and that the postoperative evolution, although closely related with the level of deterioration of vital functions and the fast reestablishment of their balance, was firmly influenced by the characteristics of the surgical procedure. As a result, the detection of the causes of major operative complications, including mortality, is basic for the continued improvement in results.[4]

The aim of this study is to determine, in the context of a university hospital of reference, the risk factors of preoperative, intraoperative, and postoperative mortality according to the type of surgery and the moment in which it is performed; depending of whether it is via elective surgery or in patients admitted for decompensation and underwent emergency surgery. Furthermore, we are intent on relating the preoperative, intraoperative and postoperative risk factors with the main causes establishing patient mortality.

Material and methods

Once consent is obtained from the hospital's bioethical committee, a cross section study was performed. Information on the surgical process was obtained through the hospital discharge report, which is directly filled-out in the patient's history. All of the patients operated in 2004, 2005, and 2006 resulting in hospital death were included in the study; independently of the type of surgical intervention performed and of the postoperative department they were assigned to.

A data base was compiled with all of the clinical, anaesthetic and surgical variations grouped according to the stages—preoperative, intraoperative, and postoperative—through which the patient process passes. The reference criteria for comorbidities and postoperative complications was followed[5-9] (Table 1).

Those patients admitted through the emergency unit with for specific decompensation were considered urgent. The elective patients were those in which the anaesthetic evaluation and surgical programming was initiated from the outpatient services.

Preoperative stage. It included patient assessment in the anaesthetic and elective surgery units. In the cases of emergency surgery, only the evaluation performed at the patient's bedside by the anaesthesiologist was taken into account.

Table 1 – Clinical and anaesthetic variables included in the study

Analysed Variables		
Preoperative stage	Intraoperative stage	Postoperative stage
Age. Sex. Physical condition (ASA). Body mass index (BMI). Preoperative diagnosis. Preoperative hospital stay. Number of postponed procedures and causes. Concomitant diseases: respiratory (COPD, OSAS, others), cardiovascular (HTN, ischaemic heart disease, heart failure, others), toxics (tobacco, alcohol, drugs), kidney diseases, blood diseases (anaemia, leukaemia, and lymphoma, others), neurological diseases (stroke, dementia, others), liver and digestive diseases, endocrine diseases (DM, hypercholesterolemia, others), neoplasia, full stomach (time last meal)	Type of surgery according to complexity (Table 2). Department performing surgery. Type of surgery according to organic structure. Anaesthetic technique performed. Procedure duration. Need for blood by-product transfusion. Intrasurgical. complications (hypotension, haemorrhagic shock, arrhythmias, ischaemic heart disease), oliguria and renal failure, endocrine (hypoglycaemia and others) fever, hypothermia, cardiorespiratory arrest	Postoperative hospital stay. Need for admission to ICU. Days in ICU. Surgical wound infection. Need for reintervention. Postoperative haemorrhaging. Need for transfusion. Clinical signs of sepsis. Respiratory problems: bronchoaspiration, bronchospasm, atelectasis, pneumonia, pneumothorax, pleural effusion, RTI, and need for orotracheal intubation. Heart problems: arrhythmia, ischaemic heart disease, heart failure. Thromboembolic accidents. Oliguria and renal failure. Multiorganic failure. Cardiorespiratory arrest

ASA indicates classification of risk according to the American Society of Anaesthesiologists; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HTN, systemic hypertension; OSAS, obstructive sleep apnoea syndrome.

Table 2 – Type of surgery according to level of complexity[10]

Group I. Extensive resections of major organs: pneumectomy, hepatectomy D, oesophageal cancer surgery with or without reconstruction, portosystemic and biliodigestive shunts, neoplasic resections in plastic surgery (PS), ear, nose & throat (ENT), and maxillofacial (MFS) with reconstruction and flap restoration, coronary artery bypass surgery, aorta and brain aneurysm resections

Group II. Interventions on major organs but with minor resections: lobectomy, gastrectomy, mediastinum tumour resections, suprarenalectomies, radical prostatectomy, radical ovary surgery, small intestine resections, colectomies and haemicolectomy, neurosurgical tumour surgery

Group III. Interventions that invade body cavities without resection of major organs or suturing of the hollow organ, as well as procedures on the thoracic cavity: thymectomies, cholecystectomies, choledochotomies, vaginal hysterectomy, thoracotomy for biopsies, splenectomy, thyroid and parathyroid resections, radical and simple mastectomy with axillary dissection, hip and knee prosthesis, spine surgery, ENT, MFS, and PS tumour surgery without microsurgery

Group IV. Eye surgery that cannot be performed with topical or retrobulbar anaesthesia, transurethral resection, turbinate surgery, micro-laryngoscopy, gastrostomies and colostomies, vaginal region operations, mediastinoscopy, quadrantectomy with axillary dissection, thoracic cardiopericardiopexy and thoracic sympathectomies. Less complex and invasive techniques: herniorrhaphies, eventrations, resection mammary nodes, amputation of uterine neck, mammary quadrantectomies, ophthalmologic surgery performed under local or retrobulbar anaesthesia, peripheral surgery on arms and legs (removal of osteosynthesis, carpal tunnel, trigger finger, hallux valgus, arthroscopes)

Intraoperative stage. This included the period from the anaesthesia to the patient transfer to the corresponding department (whether it was the critical care service or not). The types of surgery and the classification by surgical groups according to criteria of cardiac risk were considered[10] (Table 2).

Postoperative stage. This included from the patient's admittance into the postoperative service, whether it were the critical care unit or not, to the time of death.

Main variable. Mortality in the hospital was considered a main variable. Six probable causes of death were taken into account:

- Death due to heart problems, with the following diagnoses: ischaemic heart disease (myocardial infarction), heart failure (acute pulmonary oedema, right ventricular failure), and malignant arrhythmias (ventricular fibrillation and ventricular tachycardia).
- Death from cancer, previously diagnosed or during the admission procedures, there was a progressive deterioration of the patient directly related to the oncological process.
- Death by sepsis: due to the systemic inflammatory response syndrome (SIRS) that leads to an organ dysfunction, septic shock and death.
- Death due to respiratory problems when an acute respiratory failure has not been corrected with a support treatment.
- Death by haemorrhagic shock when the haemorrhage came about without response from polytransfusions and/or surgical o pharmacological treatment.
- Death by neurological problems in cases of ictus or refractory cerebral oedema.

One of the above causes of death was assigned to each patient, according to the information registered in each case history and taking into account the data reflected as the

Table 3 – Interventions performed and number of deaths

Year	Interventions, No.[a]		Deceased, No. (%)	
	Emergency surgery	Elective surgery	Emergency surgery	Elective surgery
2004	1883	10 489	105 (5.6%)	58 (0.5%)
2005	1998	10 500	107 (5.3%)	31 (0.3%)
2006	2445	11 500	132 (5.4%)	46 (0.4%)
Total	6326	32 489	344 (5.5%)	135 (0.4%)

[a] 4559, 5044, and 4802 patients that underwent major outpatient surgery in the period 2004-2005-2006 were excluded from this study.

basic and intermediate causes of death. Following an initial evaluation of the cases by the researchers JGB, AP, and RA, all of the cases were re-evaluated by the researchers AS and EJ. In the event of discrepancies, these were agreed on by a third evaluation.

The data was statistically treated with SPSS software. The results were expressed in absolute figures and percentages, as well as by means and standard deviations. The data of elective patients was compared to the emergency ones using Pearson's χ^2 test or Fisher's exact test in the cases requiring it and Student *t* test for continuous data. A multivariate analysis was performed using a multiple linear regression model to measure the grade of association between the different preoperative, intraoperative, and postoperative variables. The Pearson's χ^2 test was used to study the possible relation between qualitative variables (relation between cause of death with preoperative, intraoperative, and postoperative variables). Values <.05 were considered significant.

Results

During the study period, 2004 to 2006, a total of 53 220 patients were intervened in our hospital, 14 405 of which were outpatients with no reported deaths, which were therefore excluded from the analysis. Among the 38 815 admitted patients, there were 479 deaths during their hospital stay; 36 of these during the surgical procedure and 443 in the postoperative stage. Table 3 indicates the number and percentages of deceased patients by ages and in relation with the time of surgery, either elective or emergency.

Table 4 displays the analysis of the preoperative, intraoperative, and postoperative variables of patients deceased after elective or emergency surgery. In elective patients, the most frequent diagnosis is neoplasia. Emergency surgery was associated to type 3 surgery, located in the lower abdomen and extremities, while elective surgery was associated with type 1 surgery, located in the thorax, head, and neck.

In the multivariate analysis of risk factors (Table 5), age was linked to the number of preoperative diseases. Patients with 3 or more diseases in the preoperative stage were older (73.4 [10.5]) than those with less than 3 (69.5 [17.55]). Males showed a greater prevalence in harmful habits (*P*<.001), respiratory diseases (*P*=.005), liver diseases (*P*=.007), and neoplasia diagnosis (*P*=.044); whereas in women, a larger presence in neurological diseases (*P*=.017) was observed. Type 1 surgery was associated with heart disease and harmful habits in the preoperative stage, with the appearance of haemodynamic problems and intraoperative haemorrhaging requiring admittance to the critical care unit, transfusions in the postoperative stage and the need to re-operate. The duration of the intervention was linked to the type of surgery. Type 1 surgery lasted longer (5.1 [3.12] h) than type 2, 3, and 4 surgeries (3.2 [1.91]; 2.2 [1.27]; 1.7 [1.46] h). The close relationship between sepsis and re-operation (*P*=.0001) as well as between the latter and infection of the surgical wound (*P*=.001) should be noted.

Discussion

In our study, operative mortality of the 38 815 interventions performed with hospital admittance was slightly over 1%; 36 deaths were reported during the operation, which represented a rate of less than 1/1000 operated patients. These results were similar to those of other studies.[11-14] The profile of deceased patients during surgery was of a patient with a disease of serious prognosis (fissured aortic aneurysm, severe acute valvulopathy), subjected to emergency surgery and the final cause of death mainly being haemorrhagic shock.

In our study, there were no deaths directly related to anaesthesia (oxygenation or haemodynamic problems resulting in cardiac arrest). No incidents caused by failure of the devices involved in the perioperative handling of the patients were reported. The estimated incidence is of 2 deaths per million of procedures/year.[15]

In emergency operation patients, there was a prevalence of locoregional anaesthesia and sedation as opposed to general anaesthesia, probably due to the type of surgery and to the need for less aggression in unstable patients.

Nevertheless, the administering of locoregional anaesthesia to decompensated emergency patients is not a recommendable option and could suppose a delay in vital support treatment.

Four hundred forty-three patients passed away in the postoperative stage, most were from emergency interventions with a preoperative hospital stay of >24 h on average. Surgical

Table 4 – Characteristics of the analysed patients at the moment of surgery

	Elective surgery (n=135)	Emergency surgery (n=344)	P
Demographic data			
Age, mean (SD), y	71 (10)	73 (15)	
Gender (male/female)	67%/33%	60%/40%	
Harmful habits	37%	32%	
COPD/OSAS	21%/4%	14%/1%	
Arterial hypertension	49%	46%	
Ischemic heart disease	24%	17%	
Heart failure	14%	11%	
Kidney disease	18%	16%	
Liver disease	26%	22%	
Anaemia	8%	5%	
Neurovascular disease	21%	28%	
Diabetes/dyslipidemia	29%/25%	24%/16%	
Neoplasia diagnosis	50%	28%	.002
Comorbidity number	4.2 (1.9)	3.5 (1.9)	.001
Charlson index	3.1 (3.6)	1.9 (3)	0
Preoperative stay, d	5.5 (0.9)	8.9 (1.12)	.017
Intraoperative stage			
Type of surgery (Table 2)			.0001
Type of surgery 1/2	23%/21%	6%/17%	
Type of surgery 3/4	30%/26%	54%/23%	
Surgical speciality			
Heart	17%	7%	
Vascular	9%	14%	.001
General and digestive	33%	34%	
Neurosurgery	9%	9%	
Thoracic	7%	1%	
Traumatology	5%	24%	
Urology	9%	8%	
Anaesthesia			
General/spinal	81%/3%	46%/13%	
Plexus/sedation	5%/11%	22%/19%	.001
Procedure duration, h	3 (2.2)	2.4 (1.8)	
Intraoperative transfusion	4%	6%	
Respiratory complications	4%	2%	.007
Heart complications	10%	14%	
Kidney complications	–	1%	
Cardiorespiratory arrest	1%	1%	
Intraoperative mortality (patients), n	12	24	
Postoperative stage			
Location in critical care unit	59%	49%	
Reintervention	32%	30%	
Intraoperative transfusion	11%	14%	
Respiratory complications	56%	51%	
Heart complications	59%	51%	
Kidney complications	28%	29%	
Liver/digestive complications	13%	7%	.032
Neurological complications	25%	23%	
Infectious complications	53%	46%	
Multiorganic failure	18%	18%	
Cause of death			
Septic	25%	23%	
Respiratory	22%	26%	
Haemorrhagic	2%	8%	
Heart	35%	28%	
Neurological	10%	8%	
Evolution of oncological process	6%	7%	
Postoperative days until death	16.9 (18.7)	11.9 (17.7)	.005

Table 5 – Relationship between the preoperative, intraoperative, and postoperative variables

Variable to be studied	Variables they are related to		
	Preoperative variables	Intraoperative variables	Postoperative variables
Personal details			
Age	3 or more concomitant diseases		Without admission in critical care unit. Death after the first week
Gender			
Males	Harmful habits, kidney, respiratory, liver diseases, neoplasia	Type II and IV surgery	
Females	Neurological/psychiatric diseases	Type III surgery	
Type of surgery			
Type I	Heart, kidney diseases, harmful habits	Haemorrhage and HDN	ICU, transfer and shock, reintervention, respiratory problems
Type II	Liver diseases and neoplasia		
Type III	Vascular and respiratory diseases		Without post-surgical problems
Type IV	No PB		Neurological problems
Surgical procedure duration			
More than 2 h		Type I, II, III, HDNM problems	ICU, transfer, reintervention, sepsis
Less than 2 h		Type IV and V surgery	No need for ICU
Admission to critical care unit	Liver diseases and neoplasia	Type I and II surgery, HDNM and haemorrhage problems	Shorter postsurgical stay, haemorrhaging, MOF, reintervention
Sepsis		Type I and II surgery	Heart, kidney problems, haemorrhage, MOF, reintervention
Need for transfusion	Respiratory, kidney diseases harmful habits	Type I and IV surgery, HDNM and intrasurgical haemorrhage	Post-surgical haemorrhage, heart and kidney problems, MOF
Type of surgery			
Scheduled surgery			Death by cancer
Emergency surgery			Death by haemorrhagic shock
Surgery by organic structure			
Brain region			Death by neurological problems
Extremities, pelvis, thorax			Death by cardiac arrest and HDNM

Multivariate analysis.

delays on patients due to their pathological background can influence operative mortality; it can also reflect the delay in diagnosis or a deficiency in surgical programming. Absolute mortality was 5.5% for emergency surgery and 0.4% for elective surgery, which clearly proves that emergency intervention is a determining factor in operative mortality. Factors such as hypovolaemia, in particular haemorrhagic shock and hydroelectrolytic and acid-base balance disorders mark the differences between emergency and elective surgery patients.

The average age of deceased patients was high; the older patients having more concomitant risk factors. Cardiac complications in the postoperative stage are the most common cause of morbidity and mortality in non-cardiac surgery, a fact corroborated in our study. They represent 30% of operative deaths. Furthermore, we have objectified a correspondence between cardiac death and high blood pressure and preoperative diabetes, intraoperative and postoperative haemorrhaging and haemodynamic complications in the postoperative stage. It therefore appears reasonable to establish a strategy of preoperative evaluation that anticipates this high number of complications. However, a direct relationship has not been established with pharmacological interventions, revascularisation or even invasive intraoperative monitoring with the postoperative heart complications, except in very high risk patients.[16,17]

In relation to the surgical procedure, we have been able to relate the surgical duration with the complexity of the procedures and its complications, and the intracranial localisation of the surgery with death due to neurological problems. Acute intraoperative haemorrhage, which is associated with a state of tissue hypoperfusion, and septic shock are the main predisposition factors of multiorganic failure (MOF). As in other studies, the transfusion of blood by-products in the perioperative stage is an independent risk factor.[18,19]

There were no differences in the admittance to critical care units between emergency and elective surgery patients. Neither was there a relationship between the admission in critical care units and the pathological background. The

admission of a post-surgical patient in reanimation was related to the type of surgery (mainly group 1) and the duration of the procedure. These findings should be interpreted with caution, since the shortage of space in the critical care units is probably a reason for patients being attended to in the conventional wards.[20,21] However, the previous diagnosis of neoplasia in patients who underwent minor surgery (type 4) could explain the low application of resuscitation. Mortality of surgical patients in critical care units is estimated at 32%; most of these are patients from hospital wards and not directly from the operating theatre.[11] Furthermore, around 12% of the operated patients that were admitted into a critical care unit and then transferred to conventional hospitalisation pass away.[22] In our study and in others,[23] sepsis was the most important cause of death of patients admitted to critical care units. The sepsis was related with reintervention and surgical infection. In this respect, the strict application of the Surviving Sepsis Campaign criteria,[24] early therapy, and tight glycaemia control,[25,26] would condition improved results. The appearance of kidney problems in the postoperative stage was related with the admission in the critical care unit, sepsis and transfusion in a similar way to other studies.[27]

The advantageous factors of death due to respiratory causes were surgical (groups 1 and 2), intraoperative haemorrhage and pulmonary complications in the postoperative, especially from pneumonia and bronchoaspiration. Pulmonary oedema and mechanical ventilation—either due to acute respiratory failure or congestive heart failure—are closely related to the increase in mortality.[28-30] A background of COPD[31] and morbid obesity[32-33] are factors that stimulate ventilatory complications. Bronchoaspiration, which is infrequent during anaesthesia,[34] occurs to a greater degree in the postoperative stage, especially in elderly patients and those with mechanical ventilation. Inspiratory muscle training,[35] epidural analgesia[36-38] and minimally invasive surgery[39] can be useful in the prevention of pulmonary complications.

One of the limitations of our study was the unknown exact cause of death through post-mortem diagnosis in the necropsy; therefore, we could not evaluate discrepancies with clinical diagnoses, in particular for diagnoses of myocardial infarction and embolism.[40]

It should be taken into account that the attention and perception of patient risk levels is reduced in situations of labour fatigue and in the night shifts,[41-43] both common situations in emergency surgery. In elective surgery, patient motivation in the face of surgery and the adoption of preventative measures for heart and respiratory complications have proven to be useful; and in particular the reduction of postoperative failed organs.[44]

The quality of attention during their emergency reception or throughout the hospital stay is a determining factor, so it was proposed to carry out a profile of procedures during the surgical process[45] that includes the anaesthetic-surgical deed with a description of the possible major and minor events; and therefore facilitating the communication-interaction of the team (anaesthesiologist, surgeon, resuscitator, and nurse) or the concept of team work. The grouping of patients in centres with greater experience improves the results.[46] Along this same line of discussion, clinical audits would be useful in the critical care units[47-53] as well as the analysis of extreme situations in the emergency domain.[54,55]

The most relevant results of this study are the importance of emergency surgery as a risk factor independent of mortality; the slight influence that the pathological background would have in surgical mortality; the intraoperative events as mortality risk factors, which are only significant when the death occurs in the operating theatre. Finally, the postoperative complications would represent the main mortality risk factors, in particular sepsis, heart, and respiratory problems.

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