ORIGINAL ARTICLE

Cardiac Complications of Major Elective Non-Cardiac Surgery: Incidence and Risk Factors

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Introduction and objectives. Previous estimates of the incidence of cardiac complications following major elective surgery have all been obtained in populations with specific risk factors or in contexts that differ from those found in Spain. Our aims were to estimate the frequency of postoperative cardiac complications following major elective non-cardiac surgery in patients aged 40 years or more, and to identify associated risk factors.

Methods. Prospective observational study of consecutive patients undergoing surgery between November 1997 and October 1999.

Results. The overall incidence of postoperative cardiac complications was 9.6‰ (95% CI, 5.3‰-16‰): it was 1.9‰ (95% CI, 0.5‰-7.5‰) for superficial surgery, 36.2‰ (95% CI, 15.1‰-87‰) for visceral surgery, and 150‰ (95% CI, 67.4‰-334‰) for peripheral vascular surgery. The risk of cardiac complications was greater in patients aged 75 years or more (relative risk [RR]=9.5; 95% CI, 2.6-34.9), in those with type-I diabetes (RR=7.1; 95% CI, 2.1-24.1), systolic blood pressure ≥180 mm Hg (RR=5.8; 95% CI, 1.3-25.4), or electrocardiographic signs of ischemia (RR=25.3; 95% CI, 6-106.8), in those who had undergone deep or peripheral vascular surgery (RR=21; 95% CI, 5.4-81.6), and in those who experienced hypotensive episodes during surgery (RR=8.9; 95% CI, 2-39.1).

Conclusions. Cardiac complications occurred in 1% of consecutive patients aged 40 years or more in the 3 months following major elective non-cardiac surgery.

Key words: *Postoperative cardiac complications. Elective non-cardiac surgery. Incidence. Risk.*

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Complicaciones cardiacas en cirugía mayor programada no cardiaca: incidencia y factores de riesgo

Introducción y objetivos. Las estimaciones sobre la incidencia de complicaciones cardiacas tras la cirugía mayor programada se han obtenido en poblaciones seleccionadas por su riesgo o en contextos distintos del español. Nuestro objetivo fue estimar la frecuencia de complicaciones cardiacas postoperatorias, tras cirugía mayor programada no cardiaca, en mayores de 40 años.

Métodos. Estudio observacional prospectivo, en el que se incluyó una muestra consecutiva de pacientes intervenidos entre noviembre de 1997 y octubre de 1999.

Resultados. La incidencia de complicaciones cardiacas postoperatorias fue del 9,6‰ (intervalo de confianza [IC] del 95%, 5,3-16‰); ocurrió en el 1,9‰ de los pacientes que habían recibido una cirugía superficial (IC del 95%, 0,5-7,5‰), en el 36,2‰ de los pacientes con cirugía visceral (IC del 95%, 15,1-87‰) y el 150‰ de los pacientes con cirugía vascular periférica (IC del 95%, 67,4-334‰).

El riesgo de complicaciones fue mayor en pacientes mayores de 75 años (riesgo relativo [RR] = 9,5; IC del 95%, 2,6-34,9), con diabetes mellitus tipo 1 (RR = 7,1; IC del 95%, 2,1-24,1), presión arterial sistólica ≥ 180 mmHg (RR = 5,8; IC del 95%, 1,3-25,4), signos de isquemia en el electrocardiograma (RR = 25,3; IC del 95%, 6-106,8), cirugía visceral o vascular (RR = 21; IC del 95%, 5,4-81,6) y episodios de hipotensión (RR = 8,9; IC del 95%, 2-39,1).

Conclusiones. La frecuencia de complicaciones cardiacas en pacientes ≥ 40 años a los 3 meses de recibir una cirugía mayor programada no cardiaca fue del 1%.

Palabras clave: *Complicaciones postoperatorias cardiacas. Cirugía programada no cardiaca. Incidencia. Riesgo.*

INTRODUCTION

Most studies of postoperative ischemic complications have been undertaken in groups of patients selected on the basis of risk category.[1,2] Consequently, it is difficult to extrapolate the results to the population in which the

ABBREVIATIONS

ASA: American Society of Anesthesiologists.
ECG: electrocardiogram.
COPD: chronic obstructive pulmonary disease.
SAP: systolic arterial pressure.

majority of interventions are performed.[3] Furthermore, despite around 3 million operations being performed in Spain each year,[4] postoperative cardiac complications have been little studied in this country, either in terms of their incidence or the associated risk factors.[5,6]

For the reasons mentioned, it is of interest to undertake a prospective study in Spain to estimate the frequency of postoperative cardiac complications following programmed major noncardiac surgery in a population that is not selected according to risk category, as well as to identify variables associated with increased risk of complications in this population.

METHODS

A prospective observational study was undertaken. All patients aged over 40 years and resident in the area served by Castellón General Hospital who underwent programmed major noncardiac surgery in the general surgery, orthopedics, and urology departments were consecutively included between November 1, 1997, and October 30, 1999. Major surgery was classified by a process of exclusion of the following procedures, not considered to represent major surgery: infiltration, wound examination, reduction of closed fractures, extraction of osteosynthesis material, endoscopic biopsy, or diagnostic or exploratory endoscopy. Procedures performed with spinal anesthesia or regional intravenous anesthesia were included, along with laparoscopic surgery and therapeutic endoscopy. The following exclusion criteria were applied: pregnancy, pacemaker implantation, left bundle-branch block in the preoperative electrocardiogram (ECG), and impossibility of communication due to advanced dementia.

Follow-up was performed until 3 months after surgery, death, or the appearance of events considered postoperative cardiac complications. Following hospital discharge, participants were contacted by telephone. When events related to any of the considered outcomes were detected, 2 of the investigators reviewed the chart and clinical course of the patient in an effort to characterize the process.

Main Outcomes

The main outcome measured was the presence of a major cardiac complication, defined as the appearance of congestive heart failure, cardiogenic pulmonary edema, stable or unstable angina, myocardial infarction, severe arrhythmia (ventricular tachycardia or fibrillation), cardiac arrest, cardiac death, or sudden death. For an event to be classified as a major cardiac complication it must have appeared within 90 days of surgery, it must not have been a consequence of the terminal phase of noncardiac processes, and specified a priori diagnostic criteria must have been met for each entity considered to be a major cardiac complication, for which the definitions described by other authors were used.[7-9]

Concomitant Diseases

In addition to sociodemographic variables, the presence of the following conditions was recorded based on the patient's chart and the preanesthesia assessment, or if not mentioned, by examination of the patient and taking a medical history: diabetes, arterial hypertension, chronic obstructive pulmonary disease (COPD), kidney failure, history of cancer, stroke, transient ischemic attack, cardiac surgery, acute myocardial infarction, angina (classified according to the criteria of the Canadian Cardiovascular Society[10]), peripheral arterial diase, arrhythmias, activity limitation, substance abuse, and treatment for chronic processes prior to the preanesthesia assessment.

Preoperative Assessment

During the preoperative assessment, information was obtained on height and weight, and the body mass index was calculated.[11] In addition, systolic and diastolic arterial pressure were measured and a chest radiograph and ECG were performed. Abnormalities observed in the ECG were classified as disorders of rhythm, disorders of conduction, preexcitation, hypertrophy, ischemia, lesion, and necrosis.[12,13] Functional status was assessed according the the New York Heart Association classification.[14] The most recent values for hematocrit, hemoglobin concentration, blood glucose level, concentration of creatinine, potassium, sodium, and alanine aminotransferase, and arterial oxygen saturation were obtained from the preanesthesia assessment or the patient's chart. Physical status was assessed in the preanesthesia assessment according to the American Society of Anesthesiologists (ASA) classification.[15]

Type of Intervention or Procedure

Interventions and procedures were classified according to the 9th revision of the International Classification of Diseases.[16] Interventions were classified as intestinal,

peripheral vascular, hepatobiliary and pancreatic, renal, prostate, major orthopedic, and breast, and according to invasiveness as superficial, major orthopedic, visceral, and peripheral vascular.[17] Information was obtained on the type of anesthesia, the length of surgery, and the occurrence of episodes of hypotension during surgery and their length. In the case of hypotension, information was not collected on its origin.

Statistical Analysis

A descriptive analysis of the characteristics of the participants, the intervention, and episodes of postoperative cardiac complications was performed along with analysis of the cumulative incidence of postoperative cardiac complications as a function of different covariables. The χ^2 test or Fisher's exact test was used to compare the distribution of categoric variables, the Student *t* test was used to compare continuous variables, and the Kruskal-Wallis nonparametric test was used for comparison of data that did not obey a normal distribution. The confidence intervals (CI) of the cumulative incidence of observed cardiac complications were calculated using a binomial approach.

The relative risk (RR) of complications between different categories of the same variable was estimated using the Mantel-Cox method and the strate and stmc commands of the STATA program.[18-20] The adjusted contribution of the different risk factors was estimated by Poisson regression. The most parsimonious estimate was sought, at the same time as being plausible and close to the data on RR of developing cardiac complications. To this end, variables were included that were significantly associated with the occurrence of postoperative cardiac complications in the bivariate analysis, that maintained values for *p-values* less than or equal to .10, and improved the explanatory capacity through a reduction of at least 10% in the CI and a significant change in the likelihood ratio.[21,22]

RESULTS

During the study period, 1596 patients (94%) were identified and invited to participate from a total of 1691 surgically treated patients, according to the minimum data set. Results are presented on 1456 patients (88.2%), since 86 were rejected, 39 met 1 of the exclusion criteria, and documentation was lost in 15. In 55 patients, more than 1 surgical procedure was performed, in which case, information was only included from the first procedure.

Characteristics of the Study Patients

The mean±SD age was 64.2±11 years (65 years in men compared with 63 years in women; *P*<.0001). Habitual smokers accounted for 17% of the participants. In 32.4% of participants, ongoing treatment was being provided with 1 or more drugs with cardiovascular activity, such as aspirin, beta-blockers, angiotensin converting enzyme inhibitors, calcium channel antagonists, diuretics, or nitrates. A total of 34% of patients were hypertensive and 15% presented processes compatible with cardiovascular disease. Physical status according to ASA classification was as follows: ASA 1, 3.8% (n=55); ASA 2, 57.6% (n=832); ASA 3, 38.2% (n=552); ASA 4, 0.4% (n=6). The distribution of other covariables is shown in Table 1.

Type of Surgery

Surgery was performed in the departments of general surgery (54%), orthopedics (27%), and urology (20%). The distribution of participants according to invasiveness and site of the surgery is shown in Table 2. Surgery was performed under general anesthesia in 54% of cases (Table 2). The mean duration of surgery was 125 (67) minutes, with a range of 30 to 480 minutes; 30% of surgical interventions lasted more than 150 minutes. Ninety-two episodes of hypotension occurred, 6% of which lasted for more than 5 minutes.

Postoperative Cardiac Complications

A total of 14 cardiac complications occurred in the 90 days following surgery (Figure), with a cumulative incidence of 9.6 per 1000 interventions. In 64% of cases, complications occurred within the first 14 days of follow-up (Table 3). Four patients presented a single complication (2 cases of angina, 1 acute myocardial infarction, and 1 pulmonary edema), while the remainder presented 2 or more complications. Four episodes of cardiogenic pulmonary edema were observed (3 cases preceded by congestive heart failure and 1 by an episode of hypotension during the intervention), 4 of coronary insufficiency (with hospital readmission as a consequence, following earlier discharge), 1 acute myocardial infarction, 1 severe arrhythmia (preceded by an episode of congestive heart failure), and 4 deaths due to a cardiac complications (all preceded by congestive heart failure; in 1 case the heart failure was accompanied by pulmonary edema and in 2 cases it was preceded by episodes of hypotension during surgery).

Patient Characteristics Associated With Cardiac Complications

No complications were observed in patients aged less than 50 years. The cumulative incidence according to age group showed a positive trend, with a RR of 1.96 for each age increase of 10 years (95% CI, 1.21-3.18; *P*=.0061 for the trend) and with a clear increase above 75 years of age.

TABLE 1. Characteristics of the Patients Included in the Study*

	Number	Percentage
Total	1456	100
Age, y		
40-49	172	11.8
50-59	322	22.1
60-69	500	34.3
70-79	377	25.9
≥80	85	5.8
Men	723	49.7
Diabetes mellitus, all	156	10.7
Type 1 diabetes	42	2.9
Body mass index		
<20	20	1.4
20 to <25	295	20.3
25 to <30	612	42.0
30 to <40	490	33.6
≥40	39	2.7
COPD	112	7.7
Liver disease	29	2.0
Kidney failure	21	1.4
Cancer	399	27.4
Stroke	44	3.0
Transient ischemic attack	5	0.3
Coronary intervention	7	0.5
Myocardial infarction		
>6 months	36	2.5
3-6 months	1	0.1
<3 months	0	–
History of angina		
>6 months	27	1.8
3-6 months	3	0.2
Classification of angina†,‡		
I	9	0.6
II	9	0.6
III	2	0.1
IV	0	–
Ischemic disease$	74	5.1
Congestive heart failure‖	82	5.6
Atrial fibrillation	34	2.3
Peripheral arteriosclerosis	38	2.6

*COPD indicates chronic obstructive pulmonary disease.
†According to the criteria of the Canadian Cardiovascular Society.
‡Ten patients with a history of angina of more than 6 months did not present symptoms.
$History of acute myocardial infarction, precordial pain with exercise, use of nitrites, or Q wave in the electrocardiogram.
‖History of congestive heart failure or pulmonary edema, or compatible signs in radiographs.

TABLE 2. Characteristics of Surgery and Anesthesia

	Number	Percentage
Surgery		
Site		
Nonvisceral	566	38.9
Major orthopedic	213	14.6
Bile ducts	183	12.6
Intestinal	137	9.4
Kidney and ureter	123	8.4
Prostate	118	8.1
Breast	76	5.2
Peripheral vasculature	40	2.7
Anesthesia		
General anesthesia	789	54.2
Regional		
Spinal	560	38.5
Epidural	25	1.7
Plexus block	10	0.7
Regional intravenous anesthesia	64	4.4
Peripheral block	8	0.5
Total	1456	100

TABLE 3. Cumulative Incidence of Postoperative Cardiac Complications

Days After Surgery	Postoperative Cardiac Complications	Percentage	Cumulative Percentage
0-7	6	42.9	42.9
8-14	3	21.4	64.3
15-30	2	14.3	78.6
31-60	2	14.3	92.9
61-90	1	7.1	100
Total	14	100	

In addition to age, patient characteristics and clinical history variables that were associated with an increased risk of postoperative cardiac complications (Table 4) were that they were separated, lived alone, and were retired, as well as the presence of diabetes, incapacity, history of transient ischemic attack, acute myocardial infarction, angina, ischemic disease, congestive heart failure, atrial fibrillation, and peripheral arterial disease. The findings in the preoperative examination that were associated with an increased risk of cardiac complications were systolic arterial pressure (SAP) ≥180 mm Hg, hematocrit <35%, hemoglobin concentration <100 g/L, blood glucose level <3.9 mmol/L or ≥8.4 mmol/L, and serum creatinine concentration ≥119.7 µmol/L. Finally, the presence of cardiomegaly in the chest radiography and conduction disorders, premature ventricular contraction, or evidence of ischemia in the ECG were associated with postoperative cardiac complications. None of the 887 individuals classified as ASA class 1 or 2 (62% of all patients included) presented postoperative cardiac complications. All cases of postoperative cardiac complications occurred in patients classified as ASA class 3, with a frequency of 25 per 1000 interventions. Treatment with beta-blockers was used in 2.6% (n=38) of patients and none presented cardiac complications in the postoperative period observed.

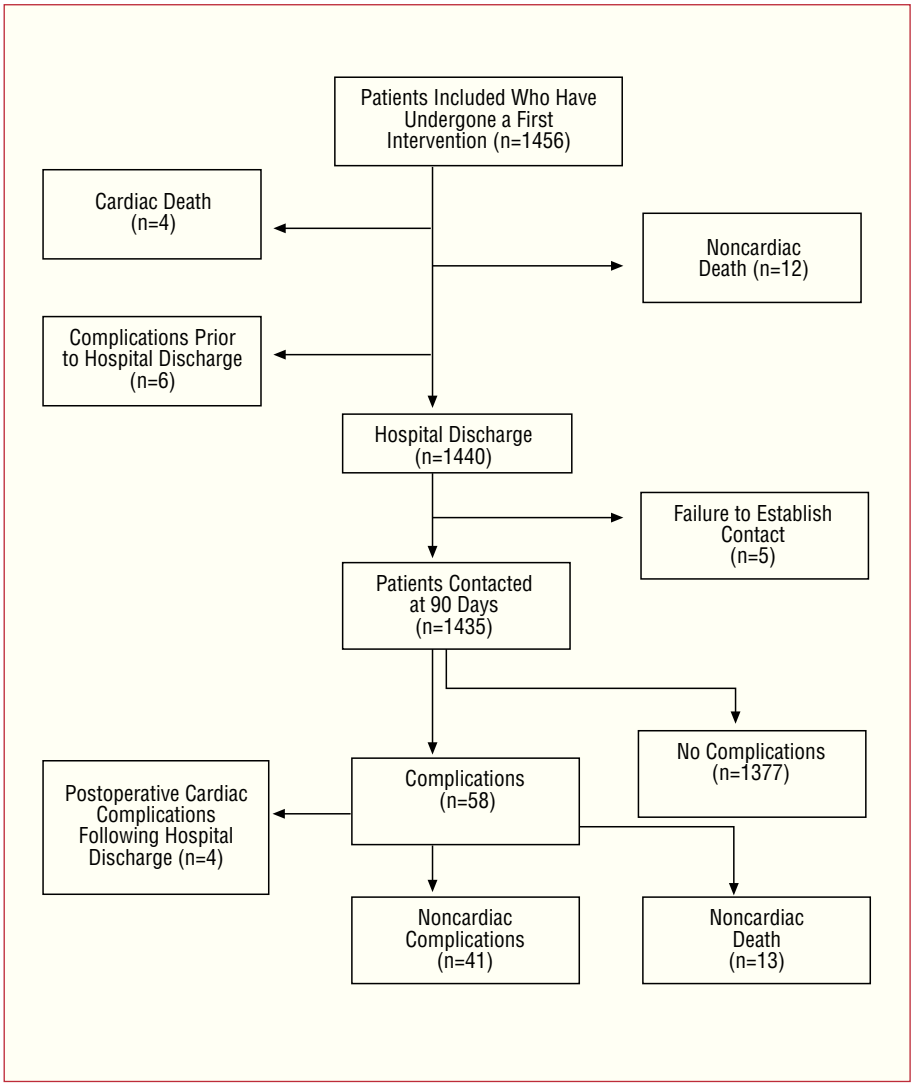

Figure. Follow-up of the patients included in the study.

Characteristics of Surgery Associated With Cardiac Complications

The surgical factors associated with an increased risk of complications (Table 5) were the type of surgery, epidural anesthesia, length of surgery or anesthesia ≥150 minutes, and episodes of hypotension during surgery. No postoperative cardiac complications were observed with surgery on the kidneys, ureter, prostate, or breast. Surgery involving manipulation of the viscera and peripheral vascular surgery together accounted for 80% of complications. The rate of complications was 1.9‰ for superficial surgery, 4.7‰ for major orthopedic procedures, 36.2‰ for visceral surgery, and 150‰ for peripheral vascular surgery. Complications were significantly more frequent in patients who underwent episodes of hypotension lasting more than 5 minutes.

Risk Factors for Cardiac Complications: Multivariate Analysis

Patient characteristics that maintained a significant independent association with the incidence of cardiac complications were age (≥75 years), the presence of type I diabetes mellitus, SAP≥180 mm Hg, and signs of ischemia in the ECG. With regards to the characteristics of surgery performed with anesthesia, the type of intervention (visceral or vascular) and the appearance of episodes of hypotension during surgery were associated with an increased risk of complications, independently of other factors (Table 6).

DISCUSSION

This is the first prospective study undertaken in Spain in which the rate of postoperative cardiac complications

TABLE 4. Patient Factors Associated With Increased Risk of Postoperative Cardiac Complications in the Bivariate Analysis*

	Postoperative Cardiac Complications						
	No	Yes	Incidence per 1000†	95% CI	RR	95% CI	*P*
Sociodemographic factors							
Age ≥75 y	222	7	21.6	11.6-40.2	5.5	1.7-17.7	.0014
Separated	12	1	76.9	10.8-546.1	11.6	1.3-100.6	.0047
Single	52	3	55.5	17.6-169.1	7.3	1.9-27.2	.0005
Retired	787	13	16.2	9.4-28	10.6	1.4-82.6	.0048
Noncardiovascular disease							
Type 1 or 2 diabetes	149	7	44.9	21.4-94.1	8.7	3-25.4	<.0001
Type 1 diabetes	37	5	119	49.5-286	21.1	6.6-67.9	<.0001
Incapacity	13	2	133.3	33.3-153.1	18.3	3.6-92	.0000
Cardiovascular disease							
TIA	4	1	200	28.2-1.419.8	27.6	2.8-271.5	<.0001
AMI	35	2	54	13.5-216.1	6.7	1.4-31.4	.0052
Angina (class II or III)	9	2	181.8	45.5-727	26.5	5-139.8	<.0001
Ischemic disease	69	5	67.6	28.1-162.3	11.1	3.5-34.4	<.0001
CHF	75	7	85.4	40.7-179.1	18.2	6.1-54.7	<.0001
Atrial fibrillation	32	2	58.8	14.7-235.2	7.3	1.6-34.6	.0031
Peripheral artery disease	33	5	131.6	54.8-316.1	23.7	7.3-76.9	.0000
Results of preoperative assessment							
SAP≥180 mm Hg‡	75	4	50.6	19-134.9	7.3	2.2-24	<.0001
Hematocrit <35%	74	3	39.5	12.7-122.4	5.1	1.4-18.9	.0064
Hemoglobin <100 g/L	20	1	47.6	6.7-338	7.8	0.9-67	.0271
Creatinine >119.7 µmol/L	134	4	29.6	11-78.4	4	1.2-13	.0128
Blood glucose level$ <3.9 mmol/L	5	1	166.7	23.5-1.183.2	43.6	4.1-461	.0000
Blood glucose level ≥8.4 mmol/L	97	4	39.2	14.7-104.5	8.9	2.3-34.3	.0001
Cardiomegaly in radiographsII	68	5	70.4	29.3-169.2	11.6	3.7-36.1	.0001
NYHA class >I	7	2	222.2	55.6-888.5	34.2	6.2-187.9	<.0001
ECG results							
PVC	24	3	111.1	35.8-344.5	16.1	4.1-62.7	<.0001
Ischemia	33	5	131.6	54.8-316.1	23.7	7.3-76.9	<.0001

*CI indicates confidence interval; RR, relative risk; TIA, transient ischemic attack; AMI, acute myocardial infarction; CHF, congestive heart failure; SAP, systolic arterial pressure; NYHA, New York Heart Association; ECG, electrocardiogram; PVC, premature ventricular contraction.
†Cumulative incidence per 1000 patients treated with the indicated characteristic.
‡Compared with SAP <180 mm Hg.
$RR of both cutoff points in the values for blood glucose compared with the risk observed in patients with blood glucose concentrations of 70 to 109 mg/dL.
IIChest radiograph in the preoperative assessment.

associated with programmed major surgery was estimated in a consecutive patient series; previous reports were based on studies performed in groups of patients selected on the basis of being at high risk.[5,6] The observed cumulative incidence of postoperative cardiac complications was approximately 10 per 1000 surgical interventions. This incidence is lower than that observed by other authors in patients aged at least 40 years with the same definition of outcome and programmed major surgery used in this study, but including emergency surgery, which was associated with 50% of the postoperative cardiac complications observed.[8,17,23]

No cardiac complications were observed in any of the 172 patients aged under 50 years included in the study. The cumulative incidence of complications following restriction of the estimate to patients aged at least 50 years was 11‰. In a study performed in the USA in individuals aged at least 50 years who underwent programmed surgery, the frequency of postoperative cardiac complications was 21.3‰.[24] It is worth noting that the study included a subgroup of higher-risk patients in whom more complications were observed than in the remaining patients (4.7% vs 1.7%; *P*<.001). That, along with the greater invasiveness of the surgery performed in both groups of patients, would explain the higher rate of complications observed by those authors. Furthermore, it is important to bear in mind that the rate of complications observed in patients included in this study may have been lower than that found in Anglo-Saxon populations due to the lower rate of ischemic heart disease in the Spanish population.[25-27]

The factors identified in this study as independently associated with increased risk of postoperative cardiac complications were age ≥75 years, the presence of type I

TABLE 5. Factors Associated With Surgery and Risk of Postoperative Cardiac Complications in the Bivariate Analysis*

	Postoperative Cardiac Complications						
	No	Yes	Incidence per 1000	95% CI	RR	95% CI	*P*
Type of intervention							
Superficial†	1063	2	1.88	0.47-7.51	1		
Major orthopedic	212	1	4.69	0.66-33.33	2.51	0.23-27.87	.4386
Visceral	133	5	36.23	15.08-87.04	19.98	3.75-106.35	<.0001
Peripheral vascular	34	6	150.00	67.39-333.88	93.79	16.51-532.99	<.0001
Anesthesia							
General	779	10	12.67	6.82-23.56	1.00		
Regional							
Spinal	558	2	3.57	0.89-14.28	0.28	0.06-1.29	.0807
Epidural	23	2	80.00	20.01-319.88	6.77	1.38-33.32	.0063
Duration							
Intervention ≥150 min	424	9	20.79	10.82-39.95	4.82	1.02-22.74	.0280
Anesthesia ≥150 min	348	9	25.21	13.12-48.45	7.69	1.63-36.41	.0023

*CI indicates confidence interval; RR, relative risk.
†Renal, prostate, breast, nonvisceral, and bile ducts.

TABLE 6. Contribution of Patient and Intervention Characteristics Associated With Increased Possibilityof Postoperative Cardiac Complications: Multivariate Analysis*

	RR	95% CI	*P*
Age ≥75 y	9.5	2.6-34.9	.001
Type 1 diabetes	7.1	2.1-24.1	.002
SAP ≥180 mm Hg	5.8	1.3-25.4	.019
Signs of ischemia in ECG	25.3	6-106.8	.0001
Visceral or vascular surgery	21	5.4-81.6	.0001
Episodes of hypotension	8.9	2-39.1	.004

*RR indicates relative risk; CI, confidence interval; SAP, systolic arterial pressure; ECG, electrocardiogram.

diabetes mellitus, SAP≥180 mm Hg, and signs of ischemia in the ECG, along with type of surgery and episodes of hypotension. These variables, considered separately or as a group, are biologically plausible and consistent with the physiological mechanism underlying the appearance of cardiac complications in the postoperative period.[28,29] However, not all of these factors have been consistently identified in other studies as independent indicators of the risk of postoperative cardiac complications.[8,17,24,30] For instance, this is the case for the presence of diabetes of any type, and more strongly for type 1 diabetes, a result which coincides with the most recent studies.[17,24,31] Arterial hypertension has only been considered as a factor to be taken into account when accompanied by signs of ventricular dysfunction.[32,33]

Finally, there is very little evidence of an effect of hemoglobin concentration or hematocrit on postoperative cardiac complications, almost certaintly because normal practice is to provide transfusion at values considered to be low (between 80 and 100 g/L for hemoglobin). When observations have been possible, the results have been variable, ranging from no identification of an effect to observation of an increased risk of morbidity and mortality in patients with the lowest concentrations of hemoglobin.[34,35] In the present patient series, those who presented a value of hematocrit or hemoglobin values less than 35% for hematocrit and <100 g/L, respectively for hemoglobin showed more complications. However, when the analysis was adjusted for other factors, less than 35% hematocrit no longer functioned as an independent risk factor for complications when the type of surgery and the appearance of episodes of hypotensive episodes were considered.

It is important to take into account that the identification of risk factors was not broken down according to the type of surgery. Consequently, it cannot be ruled out that some risk factors are applicable to certain types of surgery and not others.

The main limitation of this study lies in the reduced number of events observed in the included patients. This has an immediate effect on the accuracy of the estimates and, therefore, on the size of the confidence intervals. It is therefore advisable to take into account the value of the lower limit of the confidence intervals, which represents a more conservative estimate of the impact of a given risk factor. However, it must be remembered that the strength of the association of the different risk factors with the events of interest allows sufficient power to detect relevant associations between the variables and the rate of complications.[36]

The presence of a possible selection bias is reduced by having prospectively included a consecutive series of patients aged at least 40 years undergoing programmed surgery and having confirmed with the minimum data

set the exhaustiveness of the inclusion, with losses in relation to the minimum data set of less than 6%. On the other hand, the exclusion criteria corresponded to those necessary to ensure the interpretation of the ECG or the ability to communicate with the patient, and they affected 2.4% of patients who met criteria for age, geographic location, and surgical procedure. Follow-up was carried out until 90 days after surgery, in that way avoiding a selection bias caused by loss of patients with particular characteristics due to not taking into account cases with greater comorbidity or more severe cases in which patients die within a few days, but outside the hospital.[37] There were few losses during the follow-up period and it was only impossible to establish contact at 90 days in 5 out of 1440 patients who were discharged following surgery without complications.

Information on the presence of the risk factors was obtained prospectively from normal clinical records prior to the appearance of any adverse events; their association with the appearance of complications was generally consistent with that described in the literature. If there were any type of bias it would not be differential, meaning that the estimate of the RR would tend towards zero.[36]

The possibility of a bias due to poor classification of the results might be reduced by the fact that they were objective clinical entities, clinically relevant, and with clear diagnostic criteria. The results were defined prior to beginning the study and their comparability was confirmed, having included in the consideration of postoperative cardiac complications the same entities that were considered as such by other authors and using similar definitions.[38] The information was obtained from clinical records; this information was collected without knowledge of the overall risk assessment for each individual and the diagnoses were given in the course of normal healthcare practices. When there was any doubt, all the available information was reviewed and the result was evaluated by consensus of at least 2 investigators. However, it is important to note that the results of this study cannot be generalized to patients with pacemakers or complete left bundle branch block, since these represented exclusion criteria.

CONCLUSIONS

In this study, the incidence of postoperative cardiac complications was estimated and found to be situated around 1% at 3 months following programmed major noncardiac surgery. This observation was made in a local Spanish population rather than the Anglo-Saxon populations that have traditionally been considered in other studies. The assessment of risk factors is essential for programmed surgery, since in this context it is possible to plan the procedure, both in terms of the decision to perform surgery and the possibility of taking other measures to minimize the risk of cardiac complications.[39,40] In this respect, our study reveals certain key factors that should be taken into account. Some cannot be modified (such as age above 70 years or the type of surgery, vascular or visceral), but others allow at least some degre of control (diabetes, SAP) and even the possibility of a prior intervention to improve cardiac perfusion (in the case of a history of severe ischemic events) or more extensive monitoring during or after surgery.

Future research should assess the behavior of the different indexes for the prediction of operative cardiac risk in this population and their applicability in Spain.[41,42]

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