

Perioperative complications following major vascular surgery. Correlations with preoperative clinical, electrocardiographic and echocardiographic features

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Abstract. *Background and aim:* We investigated the incidence rate of perioperative complications following major vascular surgery, as well as identified the risk factors and preoperative clinical, electrocardiographic and echocardiographic determinants, related to these complications. *Methods:* We studied 241 patients with asymptomatic intact abdominal aortic aneurysm (AAA) subjected to open surgical repair, 182 with critical carotid stenosis subjected to endarterectomy (CEA), and 158 with severe symptomatic occlusive peripheral artery disease subjected to aortofemoral bypass (AFB). Preoperatively, all subjects provided a medical history and underwent physical, laboratory examinations, a standard ECG, and transthoracic echocardiography. *Results:* Overall, the perioperative mortality rate was 1.2%. The highest rate of complications was observed in the AAA group ($p < 0.01$). Cardiac, respiratory, renal, gastrointestinal, and vascular complications were critically higher in the AAAs. Neurological complications were more common in the CEA compared to AAAs ($p < 0.01$). Diabetic decompensation was more frequent in the AFB compared to the others ($p < 0.05$). Mortality was correlated with left atrial enlargement and uricemia ($p < 0.03$ respectively). Cardiac complications were correlated with heart rate ($p < 0.04$), QT interval ($p < 0.001$) and left ventricular mass ($p < 0.03$), pulmonary with high levels of glycaemia ($p < 0.05$) and overt diabetes ($p < 0.04$), while renal insufficiency with hypertension ($p < 0.03$), diabetes ($p < 0.01$), previous myocardial infarction ($p < 0.01$) and left anterior hemiblock ($p < 0.01$), and neurological with hypertension ($p < 0.04$) and overweight ($p < 0.01$). *Conclusions:* We report a high rate of perioperative complications in vascular patients undergoing surgical revascularization. Cardiac, respiratory, renal, hematological, and gastrointestinal complications were predominant in the AAA group. Mortality appears significantly related to left atrial dimension and uricemia. (www.actabiomedica.it)

Key words: vascular surgery, complications, risk factors, electrocardiography, echocardiography

Introduction

Despite a dramatic shift toward less invasive and less morbid endovascular interventions, open surgery still remains a mandatory choice in a fair number of patients unsuitable for the endovascular approach. At the same time, vascular surgery (VS) is associated

with high rates of perioperative morbidity and mortality. The risk of perioperative events mainly depends on the patient condition prior to surgery, the prevalence of comorbidities, and the severity and duration of the surgical procedure. Patients undergoing major VS need close perioperative monitoring, because they are at high risk of several cardiac events, renal failure, respiratory

complications, stroke and death. The high incidence of perioperative and late cardiac complications in these patients is usually associated with coronary artery disease, left ventricular (LV) dysfunction, valvular heart disease and complex cardiac arrhythmias. In addition, cardiovascular complications are the leading cause of death within 30 days after surgery. (1,2) It is therefore clear that considerable attention should be directed toward the identification of cardiovascular risk factors and preoperative ECG or Echo features, that can serve as predictors of postoperative complications and mortality. However, accurately identifying which patients are at high risk of complications or death following a vascular intervention remains difficult. Until now, many proposals and algorithms for perioperative optimization of risk assessment have been suggested. Nevertheless, randomized controlled trials have failed to identify an effective and safe intervention to prevent complications and death.

This study was conducted to assess the incidence of perioperative complications in patients undergoing elective open surgical revascularization of the three main vascular territories. At the same time, we also investigated a potential association of cardiovascular risk factors, and main preoperative ECG and Echo features, with perioperative complications, including death.

Methods

This single-center observational study was prospectively conducted in accordance with the principles of Good Clinical Practice and with the Ethical principles that have their origin in the Declaration of Helsinki. Moreover, informed written consent was obtained from all participants. The study was performed over a period of more than ten years (from January 2000 to December 2012) in collaboration with vascular surgeons. The design of the study has been in detail previously described.(3,4)

The eligible cohort was composed of 581 clinically stable patients, assigned to their first surgical revascularization, categorized into three groups based on the underlying vascular pathology: 241 patients underwent surgical repair of intact infrarenal expanding AAA (at least 5.5 cm in diameter), 182 with critical carotid artery stenosis ($\geq 70\%$) that underwent CEA,

and 158 patients with disabling lower extremity symptoms, including claudication and advanced ischemic, that were subjected to AFB. The majority of patients of the CEA and AAA groups were asymptomatic, while the remaining had minor symptoms.

In the present study, only patients with vascular disease of a single vascular bed were included. We have not included patients with more than one arteriopathy in order to avoid contamination of the results. All patients in urgent need for VS or with severe comorbidity were excluded from the study. Moreover, all patients with acute or subacute ischemic heart disease, previous myocardial infarction (MI) in the last six months, III-IV NYHA class heart failure, with a LV ejection fraction of less than 30%, and with worrisome arrhythmias such as uncontrolled atrial fibrillation and/or complex ventricular arrhythmias, were excluded. All major perioperative complications considered were recognized and stratified into categories as shown in table 1.

A baseline screening form was completed including a structured interview, as well as physical examination, laboratory tests, standard 12-lead ECG tracing and conventional transthoracic echocardiography. Technically adequate Echo images were obtained in 96.7% of patients.

All the demographic and clinical characteristics that we have considered are listed in table 2.

Standard 12 lead ECG tracing was obtained using a 3-channel Hewlett-Packard device (Cardiofax) type 1516B; the same device automatically provided heart rate, PR and QT intervals and QRS width. Data derived from automatic analysis and further ECG aspects, such as arrhythmias, repolarization and conduction disturbances, were evaluated by two independent cardiologists.

All the ECG parameters that we have considered are those listed in the table 3.

Conventional transthoracic echocardiography was performed using standard projections at rest, according to the recommendations of the American Society of Echocardiography; a 2.5 MHz sector probe (Sonos 5500 Philips) was used. Additionally, Doppler recordings were obtained from the apical chambers view. The inter and intra observer variability for Echo-doppler measurements was less than 5 % in our laboratory. All the Echo parameters that we have considered are listed in the table 4.

Table 1. Summary of perioperative complications considered

Events	
Mortality	All causes death
Cardiac	Cardiac arrest, Acute IHD, AMI, HF, Severe Cardiac Arrhythmias
Pulmonary	Acute respiratory failure/ARDS, Atelectasis, Pneumonia, Pleural effusion, respiratory acidosis, Prolonged Mechanical Ventilation
Neurological	Stroke, TIA, Mental confusion, Syncope,
Renal	Acute RF or worsening RF
Metabolic	Uncontrolled diabetes
Hematological	Bleeding, severe anemization, transfusion reaction
Gastrointestinal	Acute abdomen, Enterocolitis, Mechanical Obstruction, Colon Ischemia, Pancreatitis, Colectistitis, Peptic Ulcer, Peritonitis Ascites.
Vascular	Acute limb ischemia, rhabdomyolysis, DVT, limb amputation,
Others	Shock, Sepsis

IHD: ischemic heart disease; AMI: acute myocardial infarction; HF: heart failure; ARDS: acute respiratory distress syndrome; TIA: transient ischemic attack; RF: renal failure; DVT: Deep vein thrombosis.

Table 2. Demographic and clinical characteristics according to vascular disease

Risk factors	AAA	CEA	AFB	P value
Patients, n°	241	182	158	
Age, years	71.5±7.0	72±8.0	70±5.0	<0.001 CEA vs AAA, AFB
Females (%)	12.0	28.6	9.0	<0.001 CEA vs AAA, AFB
BSA, m ²	1.89±0.1	1.79±0.1	1.80±0.2	<0.01 AAA vs CEA, AFB
BMI, kg/m ²	26.1±3.1	25.8±3.3	25.2±3.3	
Smokers (%)	68.9	57.1	79.1	<0.01 AFB vs AAA , CEA
Systolic HTN, mmHg	149.8±22.8	156.0±22.9	154.0±23.5	<0.05 AAA vs CEA, AFB
Diastolic HTN, mmHg	86.5±9.4	84.5±9.0	84.3±9.2	<0.005 AAA vs CEA, AFB
Hypertensives (%)	92.1	96.2	93.0	
Tryglicerids > 150 mg/dL (%)	27.8	26.9	38.0	<0.05 AFB vs AAA, CEA
Cholesterol > 220 mg/dL (%)	53.9	58.8	55.7	
Glycaemia, mg/dL	97±23	108±29	108±34	<0.001 AAA vs CEA, AFB
Diabetics (%)	12.0	18.1	22.2	<0.01 AAA vs CEA, AFB
Creatininemia > 1.5 mg/dL (%)	17.0	18.7	20.3	
Hyperuricemia (%)	28.6	19.2	20.9	<0.005 AAA vs CEA, AFB

AAA: abdominal aortic aneurysm; CEA: carotid endarterectomy; AFB: aortofemoral bypass; BSA: body surface area; BMI: body mass index; HTN: hypertension.

Categorical variables are presented as percentage. Continuous variables are presented as mean ± standard deviation.

Table 3. Basal ECG features according to vascular disease

Parameters	AAA	CEA	AFB	P value
Patients n°	241	182	158	
SR (%)	95.4	91.2	90.5	<0.01 AAA vs CEA, AFB
HR b/min	71.1±14.9	70.6±14.1	72.9±14.8	
AF (%)	5.0	7.7	8.2	<0.05 AAA vs CEA, AFB
QTc, msec	418.6±26	419.4±27.4	418.5±33.8	
AVB (%)	11.6	5.5	5.0	<0.05 AAA vs CEA, AFB
RBBB (%)	6.2	7.7	8.2	
LBBB (%)	7.0	6.0	5.7	
LAFB (%)	17.8	9.3	8.9	<0.001 AAA vs EA, AFB
RBBB+LAFB (%)	8.7	4.9	5.7	
LVH (%)	24.9	28.0	25.9	
VES (%)	7.9	6.0	5.7	
ST-depression T-flattening (%)	19.9	19.8	22.8	
PMI (%)	19.5	12.1	24.7	<.05 AFB vs AAA, CEA

AAA: abdominal aortic aneurysm; CEA: carotid endarterectomy; AFB: aortofemoral bypass; SR: sinus rhythm; HR: heart rate; AF: atrial fibrillation; QTc: corrected QT interval; AVB: atrioventricular block; RBBB: right bundle branch block; LBBB: left bundle branch block; LAFB: left anterior fascicular block; LVH: left ventricular hypertrophy; VES: ventricular extrasystoles; PMI: previous myocardial infarction.

Death was defined as all-causes mortality. Perioperative mortality was defined as the percentage of patients who died during surgery or within 30 days after surgery. A perioperative complication was defined as any complication that occurred during surgery or within 30 days of surgery.

Categorical variables are presented as percentage. Continuous variables are presented as mean ± standard deviation.

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Statistical analysis

The data were expressed in percent value and evaluated using the Chi square and t tests. Continuous variables were expressed as mean values ± SD and were evaluated by a one-way analysis of variance or by a Kruskal-Wallis test, according to the normality of variance distribution. The intergroup differences were considered significant at $p < 0.05$ level.

Univariate logistic regression analysis was performed to assess the relationship of a variety of

preoperative cardiovascular risk factors, ECG and Echo features with the occurrence of perioperative complications and death. Statistical analysis was performed using SPSS software (type 24.0).

Results

The preoperative clinical, ECG, and Echo characteristics are listed in tables 2, 3 and 4 respectively. There were no significant differences regarding cardiovascular medical treatment among the three groups. Perioperative outcomes and complications are summarized in table 5.

Correlations between preoperative clinical, ECG or Echo features and perioperative complications are given in table 6.

The overall perioperative mortality rate was 1.2%. Specifically, 2.1% occurred in the AAA group and 1.3% in the AFB group. Perioperative complications occurred in more than half of the patients (53.6%), while the overall complication rate was 81.3%. The occurrence rates for none, one and multiple complications, in each type of arteriopathy considered, were:

Table 4. Basal Echocardiographic features according to vascular disease

Parameters	AAA	CEA	AFB	P value
Patients, n°	233	176	153	
ARD, mm	36.1±3.9	32.5±4.1	31.2±3.7	<0.001 AAA vs CEA, AFB
ARD > 40mm (%)	8.4	2.3	0.7	<0.001 AAA vs CEA, AFB
LAD, mm	40.8±5.2	40.3±4.9	41.6±5.1	
LAVi >30mL/m ² (%)	29.2	31.4	30.4	
IVS>12mm (%)	37.6	35.2	26.9	<0.05 AFB vs AAA, CEA
LVMi g/m ²	152.0±48	148.7±28	148.0±36	
LVEDVi, mL/m ²	57.8±11.1	53.9±11.4	56.6±12.1	<0.005 CEA vs AAA, AFB
LVEDVi >65 mL/m ² (%)	16.4	7.3	14.7	<0.001 CEA vs AAA, AFB
LVESVi mL/m ²	23.9± 5.8	19.4±4.9	22.8±7.3	<.001 CEA vs AAA, AFB
LVEF<55% (%)	13.3	9.9	17.7	<0.05 CEA vs AAA, AFB
LV Ipo/Akinesia (%)	27.4	19.2	34.2	<0.01 CEA vs AAA, AFB
Annular calcifications (%)	30.2	33.5	38.7	<0.001 AFB vs AAA, CEA
AVS moderate/severe (%)	9.0	8.2	10.7	
AVR moderate/severe (%)	14.6	10.9	12.6	
MVR moderate/severe (%)	26.3	31.8	25.7	
TVR moderate/severe (%)	5.1	4.8	6.3	

AAA: abdominal aortic aneurysm; CEA: carotid endarterectomy; AFB: aortofemoral bypass; ARD: aortic root dimension; LAD: left atrial dimension; LAVi: left atrial volume index; IVS: intraventricular septum end diastolic thickness; LVMi: left ventricular mass index; LVEDVi: left ventricular end-diastolic volume index; LVESVi: left ventricular end-systolic volume index; LVEF: left ventricular ejection fraction; AVS: aortic valve stenosis; AVR: aortic valve regurgitation; MVR: mitral valve regurgitation; TVR: tricuspid valve regurgitation.

Table 5. Summary of perioperative complications according to vascular disease

Events	Overall (%)	AAA (%)	CEA (%)	AFB (%)	P value
Patients, (n°)	581	241	182	158	
Death	1.2	2.1	0	1.3	
Cardiac	10.5	16.6	6.0	7.0	<0.01 AAA vs CEA, AFB
Respiratory	10.3	16.2	6.0	6,4	<0.01 AAA vs CEA, AFB
Renal	7.9	14.1	1.1	6.3	<0.001 AAA vs CEA, AFB
Neurological	5.5	6.2	9.3	0.0	<0.001 CEA vs AFB <0.01 CEA vs AAA
Metabolic	3.2	2.9	1,1	6.3	<0.05 AFB vs AAA, CEA
Hematological	18.9	34.3	6.0	25.3	<0.001 CEA vs AAA, AFB <0.01 AAA vs AFB
Gastrointestinal	10.7	17.8	1.1	9.5	<0.001 AAA vs CEA, AFB <0.01 AFB vs CEA
Vascular	2.2	4.6	0.0	1.3	<0.001 AAA vs CEA <0.01 AAA vs AFB
Sepsis	7.1	13.3	1.1	4.4	<0.001 AAA vs CEA, AFB
Shock	3.8	8.3	0.0	1.3	<0.001 AAA vs CEA, AFB

AAA: abdominal aortic aneurysm; CEA: carotid endarterectomy; AFB: aortofemoral bypass.

Table 6. Correlations between perioperative complications and preoperative clinical or ECG/Echo features

Perioperative complications	Preoperative features	P value
death	left atrial enlargement hyperuricemia	<0.03 <0.03
cardiac	increased heart rate increased QT interval LVM	<0.04 <0.001 <0.03
pulmonary	hyperglycemia overt diabetes	<0.05 <0.04
renal	hypertension overt diabetes previous MI LAFB	<0.03 <0.01 <0.01 <0.01
Neurological	hypertension overweight	<0.04 <0.01
Haematological	QTc AVB Family history for CVD	<0.05 <0.03 <0.03
Gastrointestinal	Overt diabetes Systolic Hypertension	<0.05 <0.001

LVM: left ventricular mass; MI: myocardial infarction; LAFB: left anterior fascicular block; QTc: Corrected QT interval; AVB: atrioventricular block; CVD: cardiovascular disease.

31.1% in AAA, 43.6% in CEA and 60.2% in AFB patients for no complications; 15.1% in AAA, 20.2% in CEA, and 7.8% in AFB patients for one complication; 53.8% in AAA, 36.2% in CEA, and 32.0% in AFB patients for more than one complications.

Cardiac complications, including shock, were critically higher in the AAA group compared to the other groups ($p<0.01$). Similarly, respiratory, renal, gastrointestinal complications, and sepsis were significantly more common in the same group compared to the others ($p<0.01$, $p<0.001$, $p<0.001$, $p<0.001$, respectively). No vascular complications were observed in the CEA group, while significant complications were found in the AAA group ($p<0.01$), albeit with small variation.

Conversely, neurological complications were significantly higher in the CEA compared to the AAA group ($p<0.01$) and haematological complications were significantly less than in the other groups ($p<0.001$). Diabetic decompensation was more frequent in the AFB group compared to the others ($p<0.05$). Overall

perioperative complication rates were significantly higher in the AAA patients in comparison to the other groups ($p<0.01$).

Univariate regression analysis demonstrated that perioperative death was associated with left atrial enlargement and hyperuricemia ($p<0.03$ respectively). Cardiac complications showed a good correlation with increased heart rate ($p<0.04$), increased QT interval ($p<0.001$) and increased LV mass ($p<0.03$), while pulmonary complications were associated with high levels of glycaemia ($p<0.05$) or overt diabetes ($p<0.04$). Acute renal failure or aggravation of pre-existent renal insufficiency expressed a good correlation with hypertension ($P<0.03$), diabetes ($P<0.01$), previous MI ($p<0.01$) and left anterior fascicular block ($p<0.01$). Neurological complications were associated with hypertension ($p<0.04$) and overweight ($p<0.01$). Finally, we observed an association between haematological complications and family history of cardiovascular disease ($p<0.03$), as well as, between gastrointestinal complications with overt diabetes ($p<0.5$), and systolic hypertension ($p<0.001$).

Discussion

In this study we observed that more than 50% of the patients presented adverse perioperative complications. Even more, these events occurred most frequently in patients with AAA. It has been reported that VS is associated with a two to four times greater incidence rate of MI or death of cardiac origin, and with a relatively wide range of perioperative cardiac complications, compared to other types of non-cardiac surgeries. (5) However, we observed a relatively low rate of perioperative mortality. Additionally, the perioperative mortality rate was found to be associated with hyperuricemia and left atrial enlargement. The mortality rates recently reported for open vascular interventions are: 0.5% for carotid revascularization procedures, 3%-4% for lower extremity procedures and approximately 5% for non-ruptured AAA repair. (6)

Specifically, perioperative mortality for elective open AAA repair in contemporary series ranges between 1%-5% and the most common cause of death is multisystem organ failure. (7) To this day, the role

of uric acid as an independent marker of the risk of cardiovascular disease remains unclear. However, the presence of preoperative hyperuricemia in patients with coronary artery disease has been associated with an increased risk of late mortality after VS and closely associated with an increased risk of 30-day mortality.(8) Currently, there is robust evidence that an increased left atrial volume index is a powerful Echo predictor of mortality in the general population and of ischemic heart disease in both sexes.(9) Our findings further confirm a close correlation between left atrial volume and perioperative mortality after elective major vascular surgery.

Cardiac complications made up for almost a sixth of all perioperative events and occurred more frequently in the AAAs than in the other groups. In addition, they were associated with QT interval prolongation and with an increase in both heart rate and LV mass. There are discordances between intraoperative heart rate, perioperative cardiac events, and outcomes of elective vascular surgery. Nevertheless, it has recently been shown that elevated preoperative heart rate is associated with perioperative adverse cardiac events after non-cardiac surgery.(10) Furthermore, QT interval prolongation on preoperative ECG has been identified as a predictor of short and long-term mortality and of increased perioperative morbidity after non-cardiac, cardiac, and vascular surgery. (11,12) Moreover, LV hypertrophy is another important marker of increased risk for in-hospital cardiac events or cardiac death in aged patients after major non-cardiac vascular surgery.(13,14) The reason is that myocardial ischemia may result from oxygen supply/demand mismatch, especially when accompanied by elevated heart rate or thickened ventricles. Similarly, QT interval prolongation could be considered a manifestation of an underlying myocardial ischemia. Both myocardial ischemia and QT interval prolongation, can lead to cardiac arrhythmias, which in turn can lead to heart failure, MI and cardiac death.

Overall, pulmonary complications were as common as cardiac complications; in the AAAs they were three-fold higher compared to the other groups. Similar results have recently been reported for AAA repair or infrainguinal bypass.(6,15) It is now well established that pulmonary complications are one of the strongest

risk factors for in-hospital mortality, prolongation of intensive care unit and hospital stay following vascular surgery. Moreover, they most frequently occur in patients of older age, female sex, as well as underweight patients and patients with morbid obesity.(15) The highest rate is, of course, observed in active smokers, in patients with advanced ischemic cardiomyopathy and chronic obstructive pulmonary disease. All these clinical features were also widely present in our series. In addition, regression analysis demonstrated that pulmonary complications were associated with high levels of glycaemia or overt diabetes. Although the impact of diabetes on postoperative outcomes after VS remains controversial, there is recent evidence that diabetes, especially when involving insulin dependence, is associated with a higher risk of postoperative complications.(16)

Nearly an eighth of the participants have developed acute renal failure or have shown a worsening of pre-existing renal failure. The group of AAAs has been affected twice as more compared to the AFB group, while the CEA group has shown a limited worsening of renal function. Previous randomized trials and registries suggest similar results in patients who underwent AFB surgery or open AAA reconstruction.(17,18) The major contributors to the development of acute renal insufficiency are hypotension and renal ischemia, which frequently occur during AAA infrarenal reconstruction. We also noticed a close correlation between renal complications and risk factors, such as hypertension or overt diabetes, and preoperative ECG features, such as previous MI and, left anterior fascicular block. To date, diabetes, hypertension, baseline renal function and previous MI have been confirmed as independent predictors of the development of acute kidney injury after coronary or vascular surgery.(3,18,19)

The overall incidence of perioperative neurological complications was 5.5%. They were more frequent in the CEA group compared to the AAA, while no complications were observed in the AFB group. Similar results have been recently reported in cases of carotid revascularization and of AAA repair.(20,21) Although hypertension is highly prevalent in patients undergoing major VS, in recent years contradictory observations have been reported on the association between blood pressure and perioperative stroke.(22,23) There have also been discrepancies in the reports of stroke

incidence rates in overweight patients undergoing vascular surgery.(22,24) However, in this study we have seen a close correlation of both hypertension and overweight with the overall neurological complications.

Uncontrolled diabetes was observed in almost 3.2% of the whole population, but it was more common in patients undergoing AFB surgery. However, it is noteworthy that a quarter of the patients in the AFB group were known diabetics. Patients with diabetes are more prone to dysregulation of glucose homeostasis during surgical stress. Stress itself may precipitate diabetic crises during or shortly after surgery, with negative prognostic consequences. Additionally, persistent hyperglycemia is already considered a risk factor for endothelial dysfunction, postoperative sepsis, impaired wound healing, and cerebral ischemia.(25)

Approximately one-tenth of all operations had gastrointestinal complications. They were more common in the AAA group, with twice the incidence rate than in the AFB group. Visceral hypoperfusion, which is associated with risk of perioperative volume depletion and shock, appears to be the common pathologic underlying mechanism.(26) Other studies report similar results and suggest that these complications are related to age and general gastrointestinal health, and are seen more frequently in men than women.(27) Moreover, we noticed a close correlation between these complications and cardiovascular risk factors such as diabetes and systolic hypertension.

The highest occurrence of hematological complications (predominantly blood loss) was seen in the AAAs (in one third of patients), followed by the AFBs (in a quarter of patients). Recently, perioperative blood loss exceeding 1L has been reported in 10% of elective AAA undergoing EVAR, and losses greater than 2L were independently associated with increased mortality and morbidity.(28) These complications were closely correlated with family history of cardiovascular disease.

In this study, vascular complications were predominantly observed in the AAA group but had a low occurrence rate (2.2%). The AAA open repair and aortoiliac bypass procedures are associated with significant periprocedural and early postprocedural risk due

to a plethora of possible, potentially co-occurring, surgical and medical complications. There is now evidence that pelvic ischemic complications and lower extremity ischemia following open infrarenal aortic reconstruction occur in 1%-2% and 1%-5% of patients, respectively.(29) Other studies report mesenteric ischemia or distal embolization of 1.6 % and 0.9% respectively, during aortoiliac bypass procedures.(30)

In the present study, there are several limitations. Firstly, we emphasize that this study is a single-center observational study and secondly the patient cohort used for this investigation was sampled from a European population and so our findings may not be directly translatable to multi-ethnic groups. In addition, even though the results have been consistently significant, our patient cohort may not appear sufficiently large. Therefore, further confirmation of these findings in a larger cohort may be beneficial. Finally, for our analysis we used univariate statistics, thus not assessing the effect of any correlations between the various cofactors considered.

Conclusions

Patients undergoing surgical revascularization of the three main atherosclerotic vascular diseases exhibited, overall, high rates of perioperative complications. Perioperative mortality was low and associated with left atrial enlargement and hyperuricemia. The majority of complications occurred in the AAAs. Cardiac complications were associated with elevated heart rate, increased QT interval and increased LV mass. Pulmonary complications were associated with high levels of glycaemia or overt diabetes. Renal complications were associated with hypertension, diabetes, previous MI, and left anterior fascicular block. Neurological complications were associated with hypertension and overweight.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g Consultancies, stock ownership, equity interest, patent/licensing, arrangement etc) that might pose a conflict of interest in connection with the submitted article.

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