Evaluation of Four Risk-Scoring Methods to Predict Long-Term Outcomes in Patients Undergoing Aorto-Bifemoral Bypass for Aorto-Iliac Occlusive Disease

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Abstract

This study was done to determine the usefulness of the American Society of Anesthesiologists (ASA) classification, the comorbidity Charlson index unadjusted (CClu), the comorbidity Charlson index adjusted by age (CCla), and the Glasgow aneurysm score (GAS) for postoperative morbidity and survival in patients treated with aorto-bifemoral bypass (AFB) for aorto-iliac occlusive disease (AIOD). A series of 278 patients who underwent AFB were retrospectively studied. For the CClu, CClu, ASA, and GAS, receiver operating characteristics curve analysis for prediction of morbidity showed area under the curves of 0.61 ($p = 0.004$), 0.59 ($p = 0.026$), 0.569 ($p = 0.087$), and 0.63 ($p = 0.001$), respectively. Additionally, univariate analysis showed that CClu ($p = 0.016$) and GAS ($p = 0.006$) were associated significantly with an increased risk of developing complications. Furthermore, CClu ($p < 0.001$) and GAS ($p = 0.001$) showed a significant association with survival. Finally, the variable age was related to morbidity ($p = 0.004$), mortality ($p = 0.038$), and survival ($p < 0.001$). The comorbidity and the age should be taken in account in clinical treatment decisions for patients with AIOD. The CClu and GAS may play a role as predictive factors for postoperative morbidity and survival after AFB.

Keywords

- atherosclerosis
- peripheral arterial disease
- risk factors
- risk-scoring methods

A variety of surgical approaches and methods are available for the management of aorto-iliac occlusive disease (AIOD) with TransAtlantic Inter-Society Consensus II (TASCII) C-D lesions. In patients with significant surgical cardiovascular risk and limb-threatening ischemia, an extra-anatomic bypass^{1–3} versus endovascular procedure^{4,5} could be considered. In patients with less surgical risk and limiting claudication or limb-threatening ischemia due to TASCII C-D lesions, aorto-bifemoral bypass (AFB) is the gold standard for treatment.¹ Nevertheless, even so, many of these patients advised AFB are older (≥ 65 years) and with one or more medical conditions

that may jeopardize the prognosis. Hence, the assessment of the patient's general condition and anatomy of the diseased segments is paramount to decide the therapeutic approach.

A formal system for assessing a patient's fitness with AIOD would be better than current practice which is to just rely on physician's opinions. A scoring system would also guide physicians on how to improve a patient's general condition for AIOD repair.

The aim of this study was to evaluate four risk-scoring systems, the Glasgow aneurysm score (GAS),^{6,7} the comorbidity Charlson index unadjusted (CClu),^{8,9} the comorbidity

Charlson index adjusted by age (CCla),^{8,9} and the American Society of Anesthesiologists (ASA) classification¹⁰ for accuracy of prediction of postoperative mortality, postoperative morbidity, 1-year survival, and long-term survival in patients undergoing elective AFB for TASCII C-D lesions. A priori, these scoring systems could be used to select those patients with high comorbidity who would not benefit from AFB, and probably a less aggressive approach could improve the outcome.

Methods

Registration of the patient's medical data in an electronic database was recorded according to the guidelines of the Ethics Committee of our institution. All data included in the database were collected from the medical records of a consecutive series of patients who underwent elective AFB at the Dr. Negrin Hospital, Las Palmas, Spain. The authorization to use these data was given by the patients in a written and informed consent. A retrospective survey was performed in 278 patients, 262 men (94.2%) and 16 women (5.8%) with mean age of 62.66 years (SD = 9.08; 95% confidence interval [CI], 61.58–63.73), who underwent AFB for AIOD in our institution between 1984 and 2004. The indications for AFB were claudication in 162 patients (58.27%) and critical ischemia (rest pain or tissue necrosis) in 116 (41.73%). The setting was a referral university tertiary care center that attends a population of ~400,000 inhabitants. All the angiograms were reviewed to confirm the diagnosis of AIOD based on TASCII. Patients with diagnostic arteriography TASCII C-D and with AFB were included. TASCII C lesions include unilateral external iliac artery (EIA) stenoses that extend into the common femoral artery (CFA), unilateral EIA occlusions that extend into the internal iliac, bilateral common iliac occlusions, and bilateral EIA stenoses more than 3 cm that does not extend into the CFA. TASCII D refers to patients with bilateral EIA occlusions, ipsilateral common and external iliac occlusions, diffuse disease of the aorta and both iliac arteries, and infrarenal aorto-iliac occlusion. Patients with diagnostic arteriography TASCII C-D and no intention of getting treated by AFB were excluded, as well as those with associated significant lesions of the renal and visceral arteries requiring simultaneous correction, and abdominal and visceral lesions.

For AFB, a transabdominal approach was used under general anesthesia in 220 patients (79%) and 58 patients (21%) had combined anesthesia (epidural and general anesthesia). In the 278 patients, no period of clamping of the renal artery was required. Fifty-five (20%) end-to-end proximal anastomosis versus 223 (80%) end-to-side were performed. The distal anastomosis was end-to-side and it was located either on the CFA: right side in 243 cases (87%) and left side in 247 patients (89%), or on the profunda femoral artery only: right side in 35 cases (12.6%) and left side in 31 patients (11.2%).

The receiver operating characteristic (ROC) curve is a graph in which the Y axis represents sensitivity and the X axis represents 1 minus specificity. Thus, for tests whose results are expressed as a continuous variable, the ROC curve

plots the true-positive rate (sensitivity) against the false-positive rate ($1 - \text{specificity}$) over a range of cutpoints. Points along the diagonal indicate results no better than chance. Points closest the upper left-hand corner indicate the cutpoints that maximize the number of true-positive results and minimize the number of false-positive results.¹¹

When comparing tests, the test with the largest "area under the ROC curve (AUC)" is considered to be the more accurate test, assuming that the goal is to balance sensitivity and specificity. An area of 1 represents a perfect test; an area of 0.5 represents a worthless test. Therefore, corresponding AUCs of postoperative morbidity, postoperative mortality, 1-year mortality, and 20-year mortality were also calculated.

The GAS was calculated from five preoperative variables. Points were awarded for age, shock, myocardial disease, cerebrovascular disease, and renal impairment using the formula $\text{GAS} = (\text{age in years}) + (17 \text{ for shock}) + (7 \text{ for myocardial disease}) + (10 \text{ for cerebrovascular disease}) + (14 \text{ for renal disease})$.⁶ To facilitate the analysis, the values for GAS obtained were divided into two categories: <65 and ≥ 65 scores.

The ASA grading was calculated retrospectively based on the criteria set down in the original description of this statistical model: the ASA classification I (healthy status); II (mild systemic disease); III (severe systemic disease); IV (incapacitating systemic disease); V (moribund, not expected to survive 24 hours with or without surgery).¹⁰ The values for ASA obtained were classified into two categories: <3 and ≥ 3 scores.

The CCI was preoperatively calculated in each patient using an electronic application.⁸ The CCI includes 19 medical conditions weighted 1 to 6 with total scores ranging from 0 to 37: peripheral vascular disease (lower limb ischemia), cerebrovascular disease, congestive heart failure, myocardial infarction, diabetes, hemiplegia, chronic obstructive pulmonary disease, dementia, connective tissue disease, peptic ulcer disease, moderate-to-severe renal disease, diabetes with organ damage, any tumor within the past 5 years, leukemia, lymphoma, metastatic solid tumor, moderate-to-severe liver disease, and/or AIDS.⁹ The index score was constructed by awarding weight to each comorbidity depending on the magnitude of the relative risk associated with each condition. An absolute number can be obtained and used for comparison. The CCI is based on the same weighted comorbid medical conditions but includes a factor for age by a decade: beyond 50 years of age, one point is added for each 10 years. This combined age-comorbidity score was validated for Charlson in 1994.⁹ According to the optimal cutoff, the values for CCIu and CCIa obtained were classified into two categories: <3 and ≥ 3 scores.

Outcome endpoints included postoperative mortality, postoperative morbidity, and long-term survival. Postoperative mortality was defined as in-hospital death or death within 30 days of the procedure. Postoperative complications were defined as any of the following complications: cardiac, renal, respiratory, any cerebrovascular complications, paraplegia, sepsis, intestinal ischemia, multiorgan failure, and ischemic complications. Cardiac disease was considered as myocardial infarction or ongoing angina pectoris, or both.

Cerebrovascular disease was defined as all grades of stroke including transient ischemic. Renal disease was defined as a serum creatinine level ≥ 135 $\mu\text{mol/L}$. Respiratory complications ranged from pneumonia to radiographic findings of pleural effusion or atelectasia. Overall long-term survival was also recorded, defined as the time from surgery until death from any cause. The study entry date was considered the day of the operation. Survivors were followed-up in the outpatient clinic, checking their actual condition (alive, death, or missing) by reviewing the medical records or the general hospital database or by telephone.

After reviewing the medical records of these patients, data were collected and included in a database created for that purpose (Microsoft Access 2000). Analyses were performed using SPSS version 14.0 (SPSS, Inc., Chicago, IL). Categorical variables were expressed as percentages, and continuous variables were expressed as mean $\pm$ SD. Comparisons between groups were made using the Student *t*-test or the Mann–Whitney *U* test for continuous variables. The chi-square test or the Fisher exact test was used for categorical variables as appropriate.

First, we analyzed whether the categorized CClu, CCl_a, ASA, and GAS were related to the postoperative mortality and postoperative morbidity using the Mann–Whitney *U* test. Next, the global survival of patients operated for TASCII C-D lesions was estimated using the Kaplan–Meier method. Differences in survival between the categories of CCl_a, CClu, ASA, and GAS were analyzed with the log-rank test. A *p* value < 0.05 was considered statistically significant.

Results

A total of 278 AFB for AIOD, with ischemia owing to TASCII C-D lesions, were performed. The patient characteristics, associated risk factors, and comorbid conditions are shown in ►Table 1.

Postoperative Morbidity

Postoperative complications were documented in conjunction with 67 (24.1%) of the 278 operations in this series: 10 patients with early failures of the graft (3.6%), 19 patients with postoperative ileus (6.8%), 13 patients developed pulmonary complications (4.7%), 17 patients developed acute renal failure (6.1%), and 7 patients developed myocardial infarction and/or cardiac failure (2.5%). There was no early postoperative graft infection. Early failures following graft procedures most often were related to performance of distal anastomosis to a disease arterial segment with compromised outflow.

First, univariate analysis revealed that CCl_a ($p = 0.016$) (►Fig. 1), CClu ($p = 0.02$), GAS ($p = 0.006$) (►Fig. 2), and older age ($p = 0.004$) were associated significantly with an increased risk of developing severe postoperative complications (►Table 2).

Second, considering CCl_a, age, CClu, ASA, and GAS values as diagnostic tests, the value of sensitivity, specificity, positive predictive value, and negative predictive value in relation to the postoperative morbidity can be appreciated in ►Table 3.

Table 1 Patient Demographics, Comorbidities, and Risk Scores

Preoperative Risk Factor	No. of Patients (%)
Male gender	262 (94.2)
Hypertension	130 (46.8)
Diabetes mellitus	91 (32.7)
Smoker	171 (61.5)
Hypercholesterolemia	101 (39.6)
Myocardial disease	79 (28.4)
Cerebrovascular disease	27 (9.7)
Renal disease (creatinine ≥ 135 $\mu\text{mol/L}$)	22 (7.9)
Chronic obstructive pulmonary disease	56 (20.1)
Age (years)	
<65	154 (55.4)
≥ 65	124 (44.6)
CCl _a	
<3	53 (19.1)
≥ 3	225 (80.9)
CClu	
<3	201 (72.3)
≥ 3	77 (27.7)
ASA	
<3	163 (58.6)
≥ 3	115 (41.4)
GAS	
<65	128 (46)
≥ 65	150 (54)

CCl_a, comorbidity Charlson index adjusted by age; CClu, comorbidity Charlson index unadjusted; ASA, American Society of Anesthesiologist classification; GAS, Glasgow aneurysm score.

Analysis of the ROC curve showed that GAS had the best AUC for predicting severe postoperative complications (AUC: 0.635; 95%CI, 0.56–0.71; $p = 0.001$). Furthermore, the ROC curve analysis for age ($p = 0.003$), CCl_a ($p = 0.004$), and CClu ($p = 0.026$) were predictive factors of postoperative morbidity (►Table 4).

Risk Factors of Postoperative Mortality

The postoperative mortality rate was 5% ($n = 14$). The most common cause of death was myocardial infarction. Univariate analysis showed that CCl_a ($p = 0.482$), CClu ($p = 0.542$), ASA ($p = 0.501$), and GAS ($p = 0.058$) were not associated with postoperative mortality. The variable age, considered as a continuous variable, was not related to postoperative mortality ($p = 0.246$). However, when this variable was categorized (<65 vs. ≥ 65 years old), young age was associated with a statistically significant decreased postoperative mortality comparing with older patients (2.6 vs. 8.1%, respectively;

Figure 1 Kaplan-Meier survival analysis of patients who underwent aorto-bifemoral bypass for TransAtlantic Inter-Society Consensus II C-D lesions using the comorbidity Charlson index adjusted by age (CCIa) (log-rank test: $p = 0.029$).

$p = 0.038$) (► **Table 2**). Moreover, the ROC curve analysis for all risk scores showed that all of them were poor predictive factors of postoperative mortality, emphasizing in CCIa, an AUC of 0.640 (95% CI, 0.48–0.77; $p = 0.077$) (► **Table 4**), and the highest negative predictive value ($>95\%$) (► **Table 3**).

Survival

In this series, only 12 patients were entirely lost at the end of the follow-up period, 160 patients survived and 106 patients died, the median overall survival being 13.78 years (95%CI, 6.12–19.84). The probability of being alive after 1, 5, 10, 15,

Figure 2 Kaplan-Meier survival analysis of patients who underwent aorto-bifemoral bypass for TransAtlantic Inter-Society Consensus II using the Glasgow aneurysm score (GAS) (log-rank test: $p < 0.001$).

and 20 years after the operation was 92, 78.8, 58.5, 46, and 23.5%, respectively.

In our series, the association between long-term survival and preoperative CCIu ($p = 0.297$) and ASA ($p = 0.339$) did not reach statistical significance (► **Table 5**). However, the values of the categorized CCIa ($p = 0.029$), GAS ($p = 0.001$), and age ($p < 0.001$) showed a clearly statistically significant association with overall survival, being all of them predictors of survival (► **Table 5**). In fact, the age had the highest AUC at 0.575 (95% CI, 0.50–0.64; $p = 0.038$), however, the least accurate predictor of long-term survival was CCIu with a corresponding AUC of 0.476 (95% CI, 0.40–0.55; $p = 0.503$) (► **Table 4**).

Discussion

The role of comorbidity in the short- and long-term prognosis of patients with AFB has not been adequately studied. The majority of series published has not taken comorbidity into account when constructing predictive models.^{2,3} The most extensive meta-analysis of data regarding morbimortality of open AFB was performed by de Vries and Hunink² indicating that it is reasonable to expect around 4.4% postoperative mortality and 12.2% complication rate. However, outcomes after AFB in the older patients with multiple comorbidities are controversial and show reasonable morbimortality.

During the past two decades, several operative risk indices have been developed by anesthesiologists and surgeons.¹⁰ The CCI is a validated measure to use with administrative data that correlates with morbimortality after several vascular surgical procedures: patients with abdominal aortic aneurysm (AAA),¹² patients with acute mesenteric ischemia,¹³ and patients after carotid endarterectomy or carotid artery stenting.¹⁴ Furthermore, the GAS was validated successfully by Samy et al⁶ confirming the accuracy of this method to predict the immediate outcome of elective open AAA repair. Unfortunately, these indices have not been validated yet in patients undergoing AFB.

In this article, the CCIa, CCIu, ASA, and GAS scoring systems were used to evaluate comorbidity in patients undergoing AFB for AIOD with TASCII C-D lesions. We hypothesized that these models could be the predictors for postoperative mortality, postoperative morbidity, and survival. These indices might be useful to select patients who, due to a high comorbidity, would not benefit from AFB.

In agreement with the current literature,^{15–18} we found that the values of the GAS, CCIa, CCIu, and age showed a statistically significant association with postoperative complications, being all of them predictors of morbidity. ROC curve showed that GAS had the best AUC for predicting postoperative severe complications. Furthermore, the negative predictive values were high compared with the positive predictive values for CCIa, CCIu, GAS, and age. This means that in patients who are suitable for AFB, these models are better to identify low-risk patients than in identifying high-risk patients. Similarly, Nesi et al¹⁵ revealed that GAS ($p < 0.05$) was associated significantly with an increased risk of developing postoperative complications in patients undergoing AAA repair. However, ROC curve analysis in their study showed an AUC of 0.626.

Table 2 Univariate Associations with 30-Day Morbidity and Mortality Rates

Univariate associations with 30-day morbidity rates (X2)					
Category	n	Complications	OR	95% CI	p Value
CCla					
<3	53	6	2.91	1.18–7.16	0.016 ^a
≥3	225	61			
CClu					
<3	201	41	1.99	1.11–3.57	0.020 ^a
≥3	77	26			
ASA					
<3	163	33	1.654	0.95–2.88	0.074
≥3	115	34			
GAS					
<65	128	21	2.240	1.26–4.03	0.006 ^a
≥65	150	46			
Age					
<65	154	27	2.24	1.28–3.92	0.004 ^a
≥65	124	40			
Univariate associations with 30-day mortality rates (X2)					
Category	n	Mortality	OR	95% CI	p Value
CCla					
<3	53	1	3.18	0.41–24.92	0.482 ^b
≥3	225	13			
CClu					
<3	201	9	1.41	0.48–4.57	0.542 ^b
≥3	77	5			
ASA					
<3	163	7	1.44	0.49–4.24	0.501
≥3	115	7			
GAS					
<3	128	3	3.30	0.89–12.09	0.058
≥3	150	11			
Age					
<65	154	4	3.29	1.01–10.76	0.038 ^a
≥65	124	10			

^aStatistically significant.^bFisher exact test.OR, odds ratio; CI, confidence interval; CCl_a, comorbidity Charlson index adjusted by age; CCl_u, comorbidity Charlson index unadjusted; ASA, American Society of Anesthesiologist [classification]; GAS, Glasgow aneurysm score.

Regarding the postoperative mortality, some investigators have raised doubt on the robustness of these models in predicting postoperative mortality after AFB surgery.^{19,20} Wolters et al¹⁹ prospectively applied various scoring systems (ASA, Acute Physiology and Chronic Health Evaluation II [APACHE-II], Physiology and Operative Severity Score for the enNumeration of Mortality and Morbidity [POSSUM],

and Simplified Acute Physiology Score [SAPS] to estimate outcomes in 107 patients undergoing AFB due to AIOD. They found no significant correlation between risk scores and outcomes. They concluded that none of the systems analyzed separately was useful to determine postoperative mortality. In keeping with them, the results of our series indicate that ASA, CCl_u, CCl_a, and GAS are poor predictors of postoperative

Table 3 Preoperative CCl_a, CCl_u, ASA, GAS, and Age Values as Diagnostic Tests

Postoperative Morbidity	Sensitivity% (95%CI)	Specificity% (95%CI)	PPV% (95%CI)	NPV% (95%CI)	Efficiency (95%CI)
CCl _a 3 < vs. ≥ 3	91.0 (83.5–98.6)	22.3 (16.4–28.1)	27.1 (21.1–33.1)	88.7 (79.2–98.1)	38.8 (32.9–44.1)
CCl _u 3 < vs. ≥ 3	38.8 (26.4–51.2)	75.8 (69.8–81.8)	33.8 (22.5–44.9)	79.6 (73.8–82.4)	66.9 (61.2–72.6)
ASA 3 < vs. ≥ 3	50.7 (38.0–63.5)	61.6 (54.8–68.4)	29.6 (20.8–38.3)	79.7 (73.3–86.2)	58.9 (53.0–64.9)
GAS 65 < vs. ≥ 65	68.7 (56.8–80.5)	50.7 (43.7–57.7)	30.7 (22.9–38.4)	83.6 (76.8–90.4)	55.0 (49.0–61.1)
Age (years) 65 < vs. ≥ 65	59.7 (47.2–72.2)	60.2 (53.3–67.0)	32.1 (23.6–40.9)	82.5 (76.1–88.8)	60.1 (54.1–66.0)
Postoperative mortality					
CCl _a 3 < vs. ≥ 3	92.8 (75.8–100)	19.7 (14.7–24.7)	5.78 (2.5–9.1)	98.1 (93.1–100)	23.4 (18.2–28.5)
CCl _u 3 < vs. ≥ 3	35.7 (7.0–64.3)	72.7 (67.2–78.3)	6.5 (0.3–12.6)	95.5 (92.4–98.6)	70.9 (65.3–76.4)
ASA 3 < vs. ≥ 3	50.0 (20.2–79.8)	59.1 (53.0–64.6)	6.1 (1.3–10.9)	95.7 (92.3–99.1)	58.6 (52.6–64.6)
GAS 65 < vs. ≥ 65	78.6 (53.5–100)	43.5 (41.1–53.6)	7.3 (2.8–11.8)	97.7 (94.6–100)	48.9 (42.8–55.0)
Age (years) 65 < vs. ≥ 65	71.4 (44.2–98.6)	56.8 (50.6–63.0)	8.1 (2.9–7.79)	97.4 (94.6–100)	57.5 (51.6–63.5)

CCl_a, comorbidity Charlson index adjusted by age; CCl_u, comorbidity Charlson index unadjusted; ASA, American Society of Anesthesiologist [classification]; GAS, Glasgow aneurysm score; CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value.

mortality, hence only comorbidity should not be handled as a predictor for postoperative mortality in these cases because patients who benefit from AFB could not be identified with these scoring systems. These numbers seem consistent, although conclusions still may be difficult to draw because of the small number of deaths. Probably, we have failed to identify a statistical association because of a type II error. Moreover, we found that ASA score had a low sensitivity for predicting postoperative morbidity and mortality. We believe that probably the ASA score may provide more accuracy in patients after AFB if it is combined with another variable such as age or frailty.¹²

Finally, in our series, the values of the CCl_a, GAS, and age showed a statistically significant association with overall survival, being good predictors of long-term survival. However, ROC curve analysis suggests that all of them are poor tests for predicting long-term survival. Also, the GAS was found to be a moderate accurate predictor of long-term survival when applied to the open repair group of the Dutch Randomized Endovascular Aneurysm Management (DREAM) trial (AUC of 0.74)¹⁸ and EUROpean Collaborators on Stent/graft Techniques for aorta Aneurysm Repair (EUROSTAR) registry, despite an AUC of 0.70 (95%CI, 0.66–0.74; $p < 0.001$).¹⁶ Similar conclusion was

found by Armitage and van der Meulen for CCI and AAA repair.¹²

Unfortunately, the performance of scoring systems for risk prediction of long-term survival in AFB is unknown, but we think that CCl_a and GAS could complement established prognostic scores in the stratification of elderly patients with a high comorbidity treated surgically with AFB for AIOD, although it should be pointed out that the greatest effect is evident in postoperative morbidity and long-term survival. In summary, our study has showed evidence to support the use of the GAS and CCI risk-scoring models for prediction of morbidity and long-term survival following AFB. Especially, we think that these scores could provide more accuracy when both are combined with another variable such as age.

Regarding the age, we believe that it was one of the most important determinants of postoperative morbimortality and survival in this patient series. Using the patient's age alone as a score, we found a statistically significant association with older patients (≥65 years) and postoperative morbidity, mortality, and long-term survival. Also, these results are consistent with previous reports that have shown that old age “per se” is a significant risk factor for morbimortality in patients undergoing elective surgery.^{21–24}

Table 4 ROC Analyses Performed for Risk-Scoring Systems

Postoperative Morbidity	AUC	95% CI	p Value
CCla	0.617	0.54–0.69	0.004 ^a
CClu	0.590	0.50–0.67	0.026 ^a
ASA	0.569	0.49–0.64	0.087
GAS	0.635	0.56–0.71	0.001 ^a
Age	0.619	0.54–0.70	0.003 ^a
Postoperative mortality			
CCla	0.640	0.48–0.77	0.077
CClu	0.579	0.44–0.71	0.318
ASA	0.573	0.43–0.71	0.359
GAS	0.603	0.45–0.75	0.196
Age	0.603	0.46–0.74	0.193
1-year mortality			
CCla	0.650	0.52–0.77	0.020 ^a
CClu	0.607	0.49–0.73	0.097
ASA	0.573	0.46–0.69	0.225
GAS	0.596	0.46–0.73	0.137
Age	0.605	0.47–0.74	0.103
20-year mortality			
CCla	0.539	0.46–0.61	0.281
CClu	0.476	0.40–0.55	0.503
ASA	0.524	0.45–0.59	0.509
GAS	0.565	0.49–0.63	0.072
Age	0.575	0.50–0.64	0.038 ^a

^aStatistically significant.ROC, receiver operating characteristic; AUC, area under the ROC curve; CI, confidence interval; CCl_a, comorbidity Charlson index adjusted by age; CC_{lu}, comorbidity Charlson index unadjusted; ASA, American Society of Anesthesiologist [classification]; GAS, Glasgow aneurysm score.**Table 5** Univariate Associations (Log-Rank Test)

Univariate associations with 1-year survival				
Category	n	1-year survival	HR 95% CI	p Value
CCla				
<3	225	0.96	2.46	0.208
≥3	53	0.92	0.58–10.54	
CClu				
<3	201	0.95	1.89	0.136
≥3	77	0.88	0.81–4.41	
ASA				
<3	163	0.96	1.46	0.369
≥3	115	0.90	0.63–3.37	
GAS				
<65	128	0.97	1.89	0.157

(Continued)

Table 5 (Continued)

Univariate associations with 1-year survival							
Category	n	1-year survival		HR 95% CI		p Value	
≥ 65	150	0.91		0.77–4.63			
Age							
<65	154	0.97		2.28		0.055	
≥65	124	0.89		0.96–5.44			
Univariate associations with long-term survival							
Category	n	5 years	10 years	15 years	20 years	HR 95% CI	p Value
CCla							
<3	53	0.92	0.76	0.58	0.28	1.73	0.029 ^a
≥3	213	0.75	0.53	0.37	0.21	1.05–2.85	
CClu							
<3	194	0.81	0.61	0.47	0.24	1.27	0.297
≥3	72	0.74	0.50	0.35	0.24	0.81–1.98	
ASA							
<3	157	0.80	0.62	0.48	0.28	1.21	0.339
≥3	109	0.76	0.53	0.40	0.13	0.82–1.78	
GAS							
<65	120	0.86	0.72	0.58	0.34	1.91	0.001 ^a
≥65	146	0.73	0.46	0.33	0.12	1.28–2.85	
Age							
<65	146	0.85	0.71	0.55	0.31	2.11	<0.001 ^a
≥65	120	0.70	0.40	0.34	0.12	1.43–3.11	

Note: n = 266; 12 patients were lost to follow-up.

^aStatistically significant.

HR, hazard ratio; CI, confidence interval; CCl_a, comorbidity Charlson index adjusted by age; CC_{lu}, comorbidity Charlson index unadjusted; ASA, American Society of Anesthesiologist classification; GAS, Glasgow aneurysm score.

There are several limitations in this study. First, those inherent to all retrospective studies. Second, this analysis only includes AFB-operated patients and we could not determine whether a survival advantage was achieved in these patients compared with those who were treated with extra-anatomic bypass versus endovascular choice. The CCI, ASA, and GAS should be measured in a prospective, randomized trial comparing the different methods, however, it is difficult because of inherent differences in patient characteristics. Finally, it must be emphasized that a type II error may have possibly occurred in the postoperative mortality because of the small number of deaths.

Conclusion

In conclusion, the age and comorbidity conditions could play a significant role in clinical treatment decisions in older patients with AIOD. Nowadays, there is no reliable prognostic index to help assess patients with AIOD preoperatively, hence we consider that the use of CCl_a and GAS could be helpful in improving the selection of elderly patients for AFB. In addition,

further research is necessary to determine whether this risk prediction tool is also effective for AIOD patients undergoing endovascular therapy versus extra-anatomic bypass.

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