

Original Article

Gender differences in perioperative complications following carotid endarterectomy: A retrospective analysis

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Abstract

Aim: This study aims to examine the distribution of major complications in patients undergoing carotid endarterectomy (CEA) based on gender. The primary objective is to assess the potential effects of gender on perioperative events in hospital.

Material and Methods: At Başakşehir Çam and Sakura City Hospital, patients aged 18 and over who underwent CEA between September 2020 and November 2023, were retrospectively analyzed. The patients were categorized into two groups based on their gender. Patient characteristics were obtained from electronic medical records. Postoperative stroke, surgical revision, hematoma, and nerve injury were defined as perioperative events.

Results: In this study, the average age of the 225 evaluated patients was found to be 65.8 ± 8.89 . There were 73 female patients (32.44%) in Group 1 and 152 male patients (67.56%) in Group 2. Two patients (0.9%) experienced a stroke during the perioperative period. Hematomas were present in 24 patients (10.7%), and nerve damage was also observed in 15 patients (6.7%). Surgical revision due to bleeding was required in thirteen patients (5.8%). Perioperative events were observed in 27 patients. Perioperative events were significantly higher in men than in women ($p=0.037$). In multivariate logistic regression analysis, male gender was found to be the predictor of perioperative events (odds ratio [OR]: 3.701; 95% CI: 1.145-11.963, $p=0.029$).

Conclusion: Our results showed that male gender may be a predictor of perioperative events in patients undergoing carotid endarterectomy. Multicenter and larger study groups may be needed for healthier results.

Keywords: Carotid endarterectomy, gender differences, perioperative events, stroke

INTRODUCTION

Carotid endarterectomy (CEA) combined with best medical management (BMT) has been proven to be superior to BMT alone in the management of high grade carotid artery stenosis [1-4]. The relative risk reduction for stroke by CEA, however, is determined significantly by surgical success and perioperative clinical outcome [3]. Both technical factors and patient related factors have been related to neurologic adverse outcome after CEA [5-7]. CEA has been observed in multiple studies, but the

results are often conflicting [8]. Some research indicates that female patients may experience higher rates of perioperative complications and poorer outcomes compared to male patients. However, other studies suggest no significant gender disparities. These inconsistent findings highlight the need for further investigation into the role of gender as a potential risk factor in the perioperative complications of CEA. The impact of gender on surgical outcomes, particularly in cardiovascular procedures like CEA, has been an area of significant research interest due to observed differences in the incidence and

CITATION

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outcomes of cardiovascular diseases between men and women. Studies have repeatedly shown that gender can influence not only the biological course of diseases but also the outcomes following surgical interventions. This disparity is crucial in understanding and optimizing perioperative care and long-term management of patients undergoing CEA [9]. Gender differences in cardiovascular disease outcomes, including surgical interventions such as CEA, have been well-documented in the literature [10-13]. Studies suggest that women and men may experience different rates of perioperative complications and long-term outcomes, possibly due to variations in anatomy, hormonal influences, and comorbid conditions [11,14]. Given these disparities, understanding the role of gender in CEA outcomes is critical for optimizing surgical care and improving patient-specific risk stratification. This study aims to further explore the impact of gender on perioperative events in CEA to provide a clearer understanding of these differences and their clinical implications.

This retrospective clinical study is designed to explore the relationship between gender and the occurrence of perioperative events in patients undergoing carotid endarterectomy. By analyzing a comprehensive set of parameters including demographic data, medical history, and postoperative outcomes, this research aims to provide a detailed understanding of how gender may influence the risk of complications and perioperative events associated with CEA.

MATERIAL AND METHODS

The study was planned and approval of Başakşehir Çam and Sakura City Hospital Ethics Committee was obtained (E-96317027-514.10-234538148) and the study was conducted in accordance with the Declaration of Helsinki Ethical Principles and Good Clinical Practices. This retrospective clinical study was conducted at Başakşehir Çam and Sakura City Hospital, focusing on patients who underwent CEA between September 2020 and November 2023.

Patient Population and Data Collection

A total of 225 consecutive patients who had underwent carotid endarterectomy procedures and who met the inclusion criteria of the study were included in this retrospective study. Inclusion criteria for the study were adult patients aged 18 years and older who underwent isolated CEA during the study period.

Patients who had previously underwent carotid endarterectomy or stenting, patients with dialysis dependent renal failure or severe liver disease, patients requiring simultaneous surgical intervention, patients requiring urgent surgical intervention and patients with incomplete medical records were excluded from the study group.

Patient data were extracted from the hospital's electronic health records system.

The primary outcomes evaluated were perioperative complications, stroke, hematoma, cranial nerve injury, need for surgical revision, and length of stay in the intensive care unit. In addition, the length of overall hospital stay was also analyzed.

Evaluation of carotid artery stenosis

Surgical treatment is indicated in asymptomatic patients with stenosis of 70 to 99 %, and in symptomatic patients with stenosis of >60 % as per the NASCET criteria. Stenosis is determined by Doppler ultrasound and CT angiography.

According to NASCET criteria, surgical treatment was considered to be indicated for asymptomatic patients with 70-99% stenosis and symptomatic patients with 60% or more stenosis. Stenosis was determined by Doppler ultrasound and CT angiography.

Surgical Procedure

All patients in the study underwent CEA under general anesthesia. Systemic heparinization and intravenous prophylactic antibiotics were administered to all patients. Selective shunt usage was applied in cases with critical contralateral carotid lesions (70-99%). In every case, the arteriotomy was repaired using either a Dacron patch or a saphenous vein patch, depending on the intraoperative findings and surgeon's preference. Out of the 225 patients, a saphenous vein patch was used in 4 patients (6.6%), while a Dacron patch was applied in the remaining 56 patients (93.3%). Near-infrared spectroscopy (NIRS) was used intraoperatively for continuous monitoring of cerebral oxygenation to guide shunt placement and ensure optimal perfusion.

Statistical Analysis

Descriptive statistics were used to summarize demographic and clinical characteristics of the study population. Continuous variables were presented as means±standard deviation, and categorical variables as frequencies and percentages. Comparisons between genders were performed using the Chi-square test for categorical data and the Student's t-test or Mann-Whitney U test for continuous data, depending on their distribution. Logistic regression was used to assess the impact of gender on perioperative events and mortality, adjusting for age, comorbidities, and medication use. Survival analysis was conducted using the Kaplan-Meier method, with log-rank tests comparing survival curves between genders. A p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using SPSS software (Version 26.0, IBM Corp).

RESULTS

In this study, the average age of the 225 evaluated patients was found to be 65.8±8.89. There were 73 female patients (32.44%) in Group 1 and 152 male patients (67.56%) in Group

2. Significant differences between gender groups were observed in hypertension, diabetes mellitus, and smoking status ($p<0.001$, $p=0.039$, $p<0.001$, respectively). Significant disparities were observed in hypertension (91.8% in women vs. 71.7% in men, $p<0.001$), diabetes mellitus (53.4% in women vs. 38.8% in men, $p=0.039$), and smoking (31.5% in women vs. 61.2% in men,

$p<0.001$), indicating higher prevalence rates of these conditions among the respective groups. Interestingly, the usage of new generation oral anticoagulants was higher in women (8.2%) compared to men (2.6%), with a p-value nearing significance ($p=0.08$). Distributions of other demographic characteristics and medication usage are shown in Table 1.

	Total (n=225)	Female (n=73)	Male (n=152)	p value
Age (mean±SD)	65.8±8.89	66.62±10.03	65.41±8.30	0.374*
Hypertension, n (%)	176 (78.2)	67 (91.8)	109 (71.7)	<0.001#
Diabetes mellitus, n (%)	98 (43.6)	39 (53.4)	59 (38.8)	0.039#
Coronary artery disease, n (%)	193 (86.2)	59 (81.4)	134 (88.2)	0.208#
Hyperlipidemia, n (%)	141 (62.7)	51 (69.9)	90 (59.2)	0.122#
Smoking, n (%)	116 (51.6)	23 (31.5)	93 (61.2)	<0.001#
COPD, n (%)	22 (9.8)	4 (5.5)	18 (11.8)	0.132#
Chronic kidney disease, n (%)	7 (3.1)	3 (4.1)	4 (2.6)	0.685#
Aspirin, n (%)	165 (73.3)	50 (68.5)	115 (75.7)	0.255#
Clopidogrel, n (%)	88 (39.1)	25 (34.2)	63 (41.4)	0.3#
Statin, n (%)	86 (38.2)	29 (39.7)	57 (37.5)	0.748#
Insulin, n (%)	25 (11.1)	73 (32.4)	152 (67.6)	0.078#
Warfarin, n (%)	13 (5.8)	4 (5.5)	9 (5.9)	0.58#
Novel oral anticoagulants, n (%)	10 (4.4)	6 (8.2)	4 (2.6)	0.08#

*:T-test, #:Chi-Square

Out of the total, 149 patients (66.2%) were evaluated as symptomatic carotid artery disease patients. No significant difference was found regarding the presence of symptoms between females and males. The average carotid artery stenosis degree was 84.06 ± 9.8 in females and 83.89 ± 10.11 in males, with no significant difference between the two groups ($p=0.91$). Sixty patients (26.7%) had critical stenosis in the contralateral carotid artery. No significant difference was observed between genders regarding the degree of stenosis in the contralateral carotid artery ($p=0.06$). The use of a shunt during the operation was present in 60 patients (26.7%), with a usage rate of 30.9% in males and 17.8% in females. A statistically significant difference was found in shunt usage between groups ($p=0.037$). Shunt usage during surgery showed a significant difference, being substantially higher in men (30.9%) compared to women (17.8%), with a statistically significant p-value of 0.037. This table highlights critical gender-based differences in clinical and procedural aspects, suggesting that men may have more complex vascular conditions, reflected in higher rates of contralateral stenosis and shunt usage during carotid surgeries. The distribution of

radiological findings, the presence of symptoms, and shunt usage variables by group are shown in Table 2. Two patients (0.9%) experienced a stroke during the perioperative period. No significant difference was found in postoperative stroke between genders. Hematomas were present in 24 patients (10.7%), and nerve damage was also observed in 15 patients (6.7%). Surgical revision due to bleeding was required in thirteen patients (5.8%). No perioperative mortality was observed in the study. In the study, postoperative stroke, nerve damage and surgical revision were evaluated as postoperative events and they were observed in 27 patients. Perioperative events were significantly higher in men than in women ($p=0.037$). The data presented in this table reveals that while there were some differences in the incidence of postoperative strokes, nerve damage, surgical revision and hematoma, between genders, none of these differences reached statistical significance. These findings collectively suggest that despite the presence of gender differences in certain preoperative risk profiles and intraoperative details, these do not translate into significant differences in immediate or long-term clinical outcomes, underscoring the effectiveness of current surgical and

postoperative management practices in providing equitable care irrespective of gender. The distribution of perioperative events, length of hospital stay, and hematoma data by group is presented in Table 3. The relationship between perioperative events and

other variables was assessed using logistic regression analysis. In multivariate logistic regression analysis, male gender was found to be the predictor of perioperative events (odds ratio [OR]: 3.701;95% CI: 1.145-11.963, p=0.029).

Table 2. Distribution of radiological findings and presence of symptoms by gender				
	Total (n=225)	Female (n=73)	Male (n=152)	p value
Presence of symptoms, n (%)	149 (66.2)	46 (63)	103 (67.8)	0.481#
Degree of stenosis (%) (mean±SD)	83.95±9.99	84.06±9.8	83.89±10.11	0.91*
Use of shunt, n (%)	60 (26.7)	13 (17.8)	47 (30.9)	0.037#
#: Chi-Square, *: T-test				

Table 3. Distribution of perioperative events by gender				
	Total (n=225)	Female (n=73)	Male (n=152)	p value
Postoperative stroke, n (%)	2 (0.9)	0 (0)	2 (1.3)	0.455#
Nerve injury, n (%)	15 (6.7)	2 (2.7)	13 (8.6)	0.083#
Surgical revision, n (%)	13 (5.8)	2 (2.7)	11 (7.2)	0.176#
Perioperative events, n(%)	27 (12)	4 (5.5)	23 (15.1)	0.037#
Hematoma, n (%)	24 (10.7)	6 (8.2)	18 (11.8)	0.41#
Stay in intensive care unit (days), m,(IQR)	1 (0)	1 (0)	1 (0)	0.977+
#: Chi-Square, +: Mann-Whitney U				

DISCUSSION

This retrospective clinical study aimed to evaluate the impact of gender on perioperative complications in patients undergoing CEA. Although CEA has been established as an effective surgical intervention for reducing stroke risk in patients with carotid artery stenosis [1-4], the influence of gender on perioperative outcomes remains a topic of ongoing debate. In our study, no perioperative mortality was observed, which is consistent with several large-scale studies, including the North American Symptomatic Carotid Endarterectomy Trial (NASCET), where mortality rates were minimal [10,11]. However, the gender-based analysis of perioperative events revealed important findings, particularly concerning the higher incidence of perioperative complications in male patients.

Our data demonstrated that perioperative events such as hematoma, nerve damage, and surgical revision were more frequently observed in male patients, and this difference was statistically significant. This result aligns with some literature that suggests men may experience higher complication rates following CEA due to more aggressive disease presentations and more complex surgical procedures, including the increased use of shunts [13]. In our cohort, shunt usage was significantly higher in male patients (30.9%) compared to female patients

(17.8%), possibly reflecting the more severe degree of carotid artery stenosis or more challenging vascular anatomy in men. Interestingly, this finding contradicts the notion that women are at greater risk of complications due to smaller arterial diameters and later onset of atherosclerosis [13]. These discrepancies highlight the complex interplay between gender, disease severity, and surgical techniques, and suggest that male patients may require more careful intraoperative management to mitigate the risks associated with their more advanced disease states.

The higher prevalence of perioperative complications in male patients could also be attributed to the more frequent use of intraoperative shunts, which is typically indicated in cases of severe stenosis or contralateral occlusion. The literature is divided on the benefits of shunt usage, with some studies suggesting that it offers protection against intraoperative ischemic events, while others report no significant impact on stroke or mortality rates [14,15]. In our study, the use of shunts was associated with higher complication rates in men, raising the question of whether the routine use of shunts in more complex cases might contribute to increased perioperative risk. This finding warrants further investigation, as understanding the specific conditions under which shunts should be employed could enhance surgical decision-making and improve patient outcomes.

Contrary to some earlier reports that suggest women have higher perioperative stroke rates following CEA [16], our study found no significant difference in the incidence of postoperative stroke between genders. In fact, the overall stroke rate in our cohort was relatively low (0.9%), which may reflect advancements in surgical techniques, perioperative care, and patient selection criteria. The absence of a gender difference in stroke rates contrasts with the findings of studies like Bisdas et al., who reported that women, particularly those who are asymptomatic, are more vulnerable to postoperative strokes [16]. The lack of significant findings in our study may be partially explained by the relatively small sample size and the single-center design, which limits the generalizability of our results. Nevertheless, it is encouraging that modern CEA protocols seem to be closing the gap in outcomes between male and female patients.

One of the more unexpected findings of our study was the higher rate of perioperative events in male patients, despite the fact that women in our cohort exhibited a higher prevalence of traditional cardiovascular risk factors, such as hypertension and diabetes. The literature has consistently shown that women often present with more severe risk profiles at the time of surgery, which could be expected to translate into higher complication rates [12]. However, our findings suggest that these risk factors may not have the same perioperative impact across genders. One possible explanation is that improvements in perioperative management, particularly in the control of blood pressure and blood glucose levels, have mitigated the risks associated with these comorbidities. Additionally, it is possible that men in our study faced other, unmeasured risk factors, such as greater disease burden or more complex atherosclerotic plaque morphology, which could account for their higher complication rates.

Another important aspect to consider is the role of surgical expertise and institutional protocols. The lack of significant gender differences in mortality and stroke rates, despite the variation in complication rates, suggests that standardized perioperative care protocols may help reduce gender disparities in outcomes. For instance, the routine use of NIRS monitoring during surgery, as implemented in our center, may have played a crucial role in minimizing ischemic events, regardless of gender. These findings emphasize the importance of consistent and high-quality surgical care in achieving favorable outcomes for all patients undergoing CEA.

Our study is not without limitations. As a retrospective analysis conducted at a single center, our findings are subject to the inherent biases associated with this study design, including selection bias and the variability of data recording in medical records. Additionally, the relatively small sample size may limit the statistical power to detect more subtle differences between genders. Future studies should aim to address these limitations by incorporating larger, multicenter datasets and employing prospective designs that allow for more rigorous control of confounding variables.

Our study suggests that male gender may be a predictor of perioperative events in patients undergoing carotid endarterectomy, despite the presence of more severe cardiovascular risk factors in women. While advancements in surgical techniques and perioperative care appear to have equalized some of the gender-based disparities in stroke and mortality outcomes, further research is needed to explore the underlying causes of the higher complication rates observed in men. Larger, multicenter studies with longer follow-up periods will be essential for validating these findings and refining risk stratification models that incorporate gender as a significant factor. Ultimately, such research will contribute to more personalized approaches to the management of carotid artery disease, improving the safety and efficacy of CEA for both men and women.

CONCLUSION

Our results demonstrated that while the overall risk of individual complications such as stroke, hematoma, and nerve injury was comparable between genders, men were more likely to experience perioperative events as a whole. These findings suggest that male gender may be a predictor of increased perioperative risk in patients undergoing CEA, despite similar demographic and clinical profiles.

Ethics Committee Approval: The study was planned and approval of the of Başakşehir Çam and Sakura City Hospital Ethics Committee was obtained (E-96317027-514.10-234538148) and the study was conducted in accordance with the Declaration of Helsinki Ethical Principles and Good Clinical Practices.

Patient Consent for Publication: The study was conducted through electronic medical records, and informed consent was not obtained from the patients.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: All authors contributed equally to the article.

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