Ultrasonographic mapping of the extracranial carotid artery bifurcation for surgical planning: gender differences

Mapeamento ecográfico da bifurcação das artérias carótidas extracranianas para planejamento cirúrgico: diferenças baseadas no gênero do paciente

Sandra Maria Pontes[1], Fanilda Souto Barros[2], Leonard Hermann Roelke[2], Maria Alice Taylor Almeida[2], João Luiz Sandri[3], Cláudio de Melo Jacques[3], Daniela Pontes Nofal[3], Sérgio X. Salles Cunha[4]

Abstract

Context: Doppler ultrasonography is an established method for diagnosis, preoperative imaging and follow-up of extracranial carotid artery disease.
Objetive: The evaluation of gender differences in carotid artery bifurcation Doppler ultrasonography mapping.
Methods: High resolution Doppler ultrasonography of 500 carotid bifurcations was performed in 192 women and 308 men before surgical treatment. Gender differences were analyzed based on B-mode, color-flow, duplex doppler transverse and longitudinal images. Diameter percent stenoses, plaque length, distal internal and common carotid artery diameters, and distance from the carotid bifurcation to the ear lobe were compared. Mean, standard deviation, minimum and maximum values were described. Statistical comparisons were performed based on Student's t and $\chi 2$ tests.
Results: Carotid stenoses averaged 70±11% (30-95%) in women and 72±12% (40-98%) in men (p=0.013). The prevalence of 90-99% stenosis was greater in men, 14.3 vs 7.8% (p=0.029). Carotid plaques were longer in men, 2.3±0.8 vs 1.9 ±0.6 cm (p<0.001). Mean diameters of the distal internal carotid artery, 4.9±0.9 vs 4.6 ±0.8 mm, and of the common carotid artery, 7.6±1.3 vs 7.1±1.4 mm, were greater in men (p=0.001). Th e distance from the ear lobe to the bifurcation was also greater in men, 5.9±1.1 vs 5.3±0.9 cm (p<0.001).
Conclusions: Doppler ultrasonography preoperative mapping demonstrated that the parameters measured were greater in men than in women. Detailed planning of carotid plaque treatment must take into consideration individual differences such as those associated with the patient's gender.

Keywords: ultrasonography; carotid stenosis; surgery.

Resumo

Contexto: A ecografia das artérias carótidas extracranianas já se estabeleceu como método diagnóstico de imagem pré-operatória, e para seguimento de pacientes.
Objetivo: Avaliar diferenças do mapeamento ecográfico em função do gênero masculino ou feminino dos pacientes.
Métodos: Ultrassonografia de alta resolução foi realizada antes do tratamento cirúrgico de 500 bifurcações carotídeas em 192 mulheres e 308 homens. Análise de diferenças baseadas no gênero foi feita em imagens modo B e fluxo a cor, transversal e longitudinal, e medidas duplex doppler de velocidades. Porcentual de estenose expressa em redução de diâmetro, comprimento de placa, diâmetros das artérias carótida interna distal e comum, e distância da bifurcação ao lóbulo da orelha foram comparados. Média, desvio padrão, mínimo e máximo foram descritos. Comparações estatísticas foram baseadas em testes *t* de Student e do χ^2.
Resultados: Estenoses carotídeas mediram 70±11% (30-95%) em mulheres e 72±12% (40-98%) em homens (p=0,013). Prevalência de estenoses no intervalo 90-99% foi mais alta em homens, 14,3 *vs* 7,8% (p=0,029). As placas foram mais extensas nos homens, 2,3±0,8 *vs* 1,9±0,6 cm (p<0,001). O diâmetro médio foi maior nos homens, tanto da carótida interna distal, 4,9±0,9 *vs* 4,6±0,8 mm, como da carótida comum, 7,6±1,3 *vs* 7,1±1,4 mm (p=0.001). A distância da bifurcação ao lóbulo da orelha foi maior nos homens, 5,9±1,1 *vs* 5,3±0,9 cm (p<0,001).
Conclusões: O mapeamento ecográfico demonstrou que as medidas analisadas foram maiores em pacientes do gênero masculino. O planejamento detalhado do tratamento da placa carotídea deve considerar diferenças individuais como as associadas ao gênero do paciente.

Palavras-chave: ultrassonografia; estenose das carótidas; cirurgia.

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[1] PhD in Medicine from Fundação Técnica e Educacional Souza Marques – Rio de Janeiro (RJ), Brazil.
[2] PhD in Medicine from Universidade Federal do Espírito Santo – Vitória (ES), Brazil.
[3] PhD in Medicine from Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória – Vitória (ES), Brasil.
[4] PhD in Biomedical Engeneering from Marquette University – Milwaukee (Wisconsin), United States.
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Introduction

Echography has been established as a fundamental feature in the diagnosis, treatment, preoperative mapping, and follow-up of extracranial carotid artery stenosis[1-10]. Initially, in the 1980's, color-duplex echography (or Doppler ultrasonography – DUS) was used to select patients for contrast angiography, the method traditionally used for carotid endarterectomy planning. Alternative diagnostic protocols were introduced when scientific studies showed Doppler ultrasonography – a non-invasive, low-cost method - to be an alternative to contrast angiography, which is an invasive and expensive method, besides causing complications in some patients. Noninvansive ultrasonography includes additional advantages over luminography – the study of vessel lumen by longitudinal imaging provided by the radiographic method of contrast angiography. Doppler ultrasonography provides allows cross-sectional luminography, measurements of flow velocity and direct visualization of the atheromatous plaques. Thus, the combination of DUS and contrast angiography or, more recently, computed tomography (CT) angiography and magnetic resonance angiography (MRA)[11] has created a philosophy of double exams as the first and second opinion on the carotid treatment planning.

An unusual alternative has been a protocol involving two independent echographic examinations: the first a diagnostic test and the second a preoperative mapping[1]. Such preoperative mapping collects detailed information that helps in the surgical treatment, but is not necessary to the diagnosis. This paper analyzes data obtained by ultrasonographic mapping of the carotid artery of patients with indication for endarterectomy due to symptoms, risk factors and/or previous diagnostic ultrasonography. The values of measurements that are helpful in planning carotid surgery vary between individuals, justifying preoperative mapping.

Surgical practice takes into consideration individual differences. including those related to gender, which have always been focus of attention. The objectives of this study were to analyze descriptive statistical variables related to DUS findings and to determine differences related to gender. The null hypotheses tested refer to equalities and potential inequalities of preoperative DUS findings between genders.

Methods

Inclusion and exclusion criteria, sample characteristics, echographic methods used for extracranial carotid bifurcation mapping, and statistical analysis are described in this section. The ethical principles of patients' anonymity were rigorously followed in clinical data report. Principles of ethical physician-patient relationship were in compliance with our non-invasive laboratory protocol.

Since we did not have access to previous data to estimate an appropriate sample size, the number of cases of our sample was based on data from relevant international clinical trials[12,13]. Consecutive cases were analyzed to determine the adequate number of cases to be included. Statistical analysis after the inclusion of 500 cases showed significant differences, which justifies the publication of our findings without additional further recruitment of patients.

Inclusion criteria

Patients were randomly selected as they were referred to the Angiolab Vascular Laboratory, Vitória (ES), Brazil, which medical staff has over ten years of experience with vascular ultrasonography. Data were collected consecutively, based on the appointment date. Only one carotid bifurcation per patient was included in the study, in order to avoid the bias of including unilateral data in some patients and bilateral data in others. In cases of bilateral mapping, the bifurcation with higher-grade stenosis was selected for inclusion in the study.

Exclusion criteria

In cases of bilateral mapping, the bifurcation with the lowest estimate for stenosis was excluded of the analysis. Incomplete data were also excluded: a) difficulty in estimate the appropriate percentage of stenosis or arterial diameters at arterial wall calcification with acoustic shadowing; b) conflicting data in single measurements of carotid plaque longitudinal extension.

Sample characteristics

This study included 500 patients, that is, 500 carotid bifurcations of 192 females and 308 males. Mean age of both groups were 72±9 years, ranging from 45 to 95 and from 41 to 95 for females and males, respectively (p=0.91; unpaired Student's *t* test). Right-to-left bifurcation ratio was similar: 55%/45% (n=105/89) and 49%/51% (n=152/156) for females and males, respectively (p=0.35; χ^2 test).

Carotid ultrasonography

Doppler ultrasonography was performed with high-resolution instruments (Philips, IU 22 *Intelligent*

Ultrasound and HDI-5000), using 5 to 13 MHz transducers. The protocol included: a) B-mode gray-scale or color-coded images with several anatomical measurements (Figure 1 and 2); b) duplex Doppler ultrasound imaging, with measurements of flow velocity in the internal, external, and common carotid arteries and at point of maximal stenosis (Figure 3); c) Doppler color flow mapping; d) longitudinal and cross-sectional graphs for carotid bifurcations. The report also included qualitative descriptions of the plaque as homogeneous or heterogeneous, calcified or non-calcified and irregular or regular surface.

The measurements analyzed in the study were: a) estimates of carotid stenosis based on anatomical and functional analysis of Doppler flow velocity; b) plaque extension; c) distal diameter of the internal carotid artery; d) diameter of the common carotid artery; e) level of carotid bifurcation in relation to the ear lobe.

Statistics

Data obtained from men and women were analyzed separately. Statistical tests were performed in Excel® for windows. Stenosis prevalence was divided into intervals: 90-99%, 80-89%, 70-79%, 60-69%, 50-59%, and <50%. Gender differences of continuum variables (stenosis percentage, plaque extension, bifurcation diameter and level) were identified by unpaired Student's *t* test. Differences regarding interval prevalence between genres were compared by the χ^2 test.

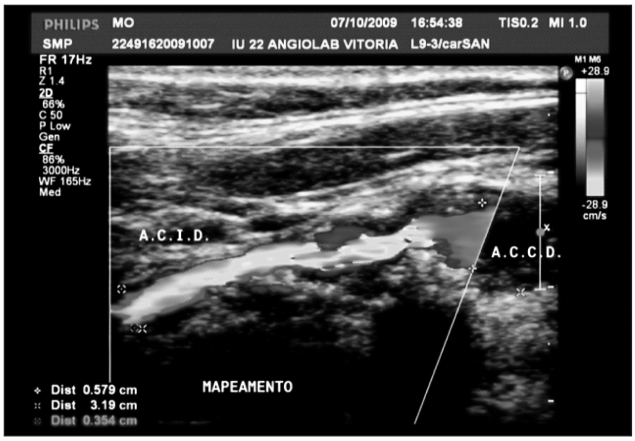

Figure 1. Longitudinal color echography image showing distal and internal carotid arteries. Note the estimates of plaque extension and distal common carotid artery, distal internal carotid artery and minimum residual lumen. The distance between the plaque and the ear lobe is estimated by the position of the transcutaneous transducer.

Results

Carotid stenosis

The mean degree of carotid stenosis was 70±11% (30 to 95%) for women and 72±12% (40 to 98%) for men. Despite the similarity of results between genres, the difference was statistically significant (p=0.013). Table 1 depicts the prevalence of stenosis for each of the aforementioned intervals. Only the prevalence in the 90-99% interval, which was higher in males, was statistically significant.

Plaque extension

Plaques were significantly longer in men (2.3±0.8 cm – 0.3 to 5 cm) compared to women (1.9 ±0.6 cm – 0.3 to 3.7 cm;

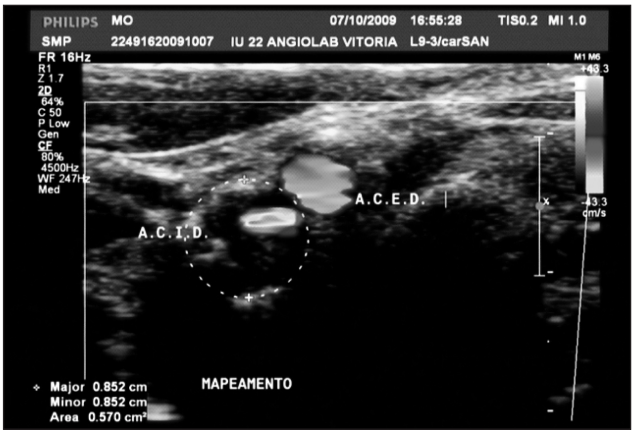

Figure 2. Cross-sectional echographic imaging of the internal carotid artery in minor lumen region. Estimates of low axis of the elliptical lumen (more common) or diameter of a circular lumen and original artery diameter at the point of highest stenosis.

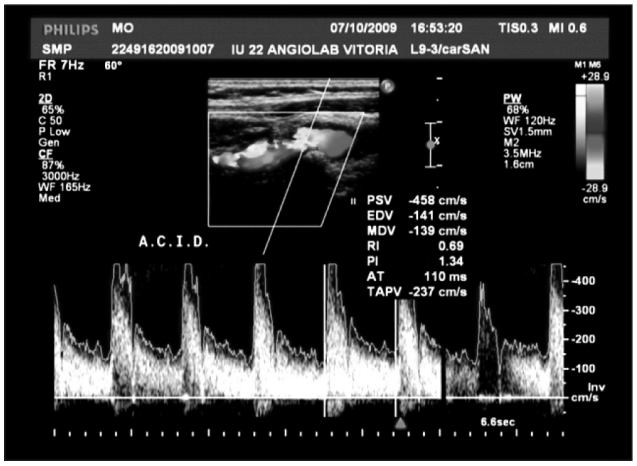

Figure 3. Duplex Doppler imaging showing high velocities at the point of peak stenosis of the proximal internal carotid that confirm anatomical findings.

p<0.001). Table 2 shows the prevalence of plaque extension for three intervals: minor, median, and major. Comparison between genders showed higher prevalence of plaques less than 2 cm long in women and plaques more than 3 cm in men. The vast majority of plaques were less than 3 cm in both genders.

Distal diameter of the internal carotid artery

The diameter of the internal carotid artery distal to the bulb was significantly greater in men (4.9±0.9 mm – 2.0 to 9.0 mm) than in women (4.6±0.8 mm – 2.0 to 8.0 mm; p=0.001). Table 3 shows that the comparison of specific diameters found large or small carotid arteries carotid in both men and women. However, prevalence of distal internal carotid diameter between 4 and 5 mm was higher in females and from 5 to 6 mm in males.

Diameter of the common carotid artery

The common carotid artery diameter was significantly higher in men (7.6±1.3 mm – 3.7 to 11.8 mm) than in women (7.1±1.4 mm – 4.0 to 10.0 mm), with p<0.001. Table 4 shows a high prevalence of diameter less than 7 mm in females, and more than 8.5 mm in males. Most common carotid arteries in both genders were in the 7.0 to 8.5 mm interval.

Carotid bifurcation level

The distance from the ear lobe to carotid bifurcation was significantly greater in men (5.9±1.1 cm – 2.5 to 10.0 cm) as compared to women (5.3±0.9 cm – 3.0 to 8.0 cm), with p<0.001. Table 5 shows that even though the prevalence was low, women presented higher bifurcations more frequently, which could be a contraindication for surgical treatment. Most bifurcations in women were located 4 to 6 cm from the ear lobe, while most bifurcations in men were located at a distance of more than 6.0 cm.

Table 1. Carotid bifurcation stenosis.

Interval	Females (n=192)	Males (n=308)	Probability
90–99%	7.8% (n=15)	14.3% (n=44)	p=0.029
80–89%	20.8% (n=40)	24.4% (n=75)	p=0.36
70–79%	38.0% (n=73)	34.1% (n=105)	p=0.37
60–69%	25.5% (n=49)	20.1% (n=62)	p=0.16
50–59%	4.7% (n=9)	6.2% (n=19)	p=0.48
<50%	3.1% (n=6)	1.0% (n=3)	p=0.078

Table 2. Carotid plaque extension.

Interval	Females (n=192)	Males (n=308)	Probability
<2 cm	50.0% (n=96)	33.4% (n=103)	p<0.001
2–3 cm	42.7% (n=82)	46.4% (n=143)	p=0.42
≥3 cm	7.3% (n=14)	20.1% (n=62)	p<0.001

Table 3. Diameters from distal internal carotid artery to carotid bulb.

Interval	Females (n=192)	Males (n=308)	Probability
<4 mm	12.0% (n=23)	10.1% (n=31)	p=0.50
4.0–4.9 mm	49.0% (n=94)	36.7% (n=113)	p=0.007
5.0–5.9 mm	30.2% (n=58)	39.6% (n=122)	p=0.033
≥6.0 mm	8.9% (n=17)	13.6% (n=42)	p=0.11

Table 4. Diameters representing the common carotid artery.

Interval	Females (n=192)	Males (n=308)	Probability
<7 mm	36.5% (n=70)	23.4% (n=72)	p=0.002
7.0–8.4 mm	47.9% (n=92)	50.6% (n=156)	p=0.55
≥8.5 mm	15.6% (n=30)	26.0% (n=80)	p=0.007

Table 5. Distance between ear lobe and carotid bifurcation.

Interval	Females (n=192)	Males (n=308)	Probability
<4 cm	5.7% (n=11)	1.3% (n=4)	p=0.005
4.0–5.9 cm	63.5% (n=122)	37.3% (n=115)	p<0.001
≥6.0 cm	30.7% (n=59)	61.4% (n=189)	p=0.001

Discussion

This section emphasizes: a) addresses the value of the carotid ultrasonographic mapping as an essential exam for open or endovascular extracranial catorid treatment planning; b) selection of ultrasonographic variables evaluated; c) comparative analysis between male and female genders. The results of the comparative statistical analyses justify the discussion on the importance of a second DUS examination and on the variables chosen for analysis, besides emphasizing that individual variations should be taken into account in treatment planning.

Preoperative ultrasonographic mapping is a complementary method to the initial diagnosis and restricted to patients with indication for surgery. It is performed strictly on the side that is being treated. A complementary and specific mapping should not be included in diagnostic ultrasonography in order to avoid high costs, for the majority of patients evaluated in non-invasive vascular laboratories are candidates to medical rather than surgical treatment.

Doppler ultrasonography has a well-established role in the evaluation of patients referred to surgery. In a reference service, almost 90% of carotid bifurcation operations were preceded by an ultrasonographic study[10].

Doppler ultrasonography has also been regarded as an essential method in the perioperative evaluation of carotid endarterectomies[2,5]. The location and length of the incision have been guided by ultrasonography[5], but ultrasonography is so sensitive that is has allowed endarterectomy in carotid previously diagnosed with occlusion by other radiographic or RMI techniques[14]. Some reference centers already use it as a guide technique in endovascular procedures[4,7].

The importance of ultrasonographic evaluation of the extracranial carotid arteries based on correlations between anatomic measurements and flow velocities has been emphasized in the literature[3,15]. Particularly, DUS exams showing high degree stenosis (more than 80%) and non-significant stenosis (less than 50%) have high positive predictive values, when compared to "luminographic" methods, such as contrast angiography. For mid-range stenosis (60 to 80%), DUS positive predictive values have been increased when high flow velocity has been added to the measurements.

The term arteriography, popularly associated with radiologic luminography has been misused. Such technique is not actually "arteriographic", for it does not yield direct information on the arterial wall or on atheromatous lesions. Besides this technical failure, radiological luminography has shown severe complications rates of 0.4 to 1.2% in studies of carotid endarterectomy[16,17]. In medical practice, the increase in the number of asymptomatic patients currently treated has minimized the need for detailed information about intracranial arteries such as the aortic arch. Ultrasonography has been regarded as a reliable imaging technique for the assessment of patients examined immediately after symptoms onset[18].

Echography, on the other hand, is a true arteriography of the carotid bifurcation wall, showing the degree of stenosis, plaque extension, the characteristics of the atheromatous plaque, including ulceration, the level of the carotid bifurcation and residual lumen diameters. Studies of echographic characterization have shown that unstable plaques are associated with higher incidence of symptoms on plaque follow-up and at endovascular treatment[19,20]. Cross-sectional ultrasonographic images explain why radiologic luminography may underestimate the degree of stenosis in the presence of elliptic lumens (the majority of cases) [11] or even in cases of overlapping images of the internal and external carotid arteries. Besides that, color Doppler mapping allows indirect evaluation of severe anomalies of the aortic arch or intracranial arteries.

It should be emphasized however that the measurements of flow velocity are influenced by the heart rate and rhythm, by carotid stenosis, tortuosities or contralateral occlusion, or by the patients' gender. In such instances, the images, allow for correction of stenosis estimates. In our service we have moved on from a diagnostic ultrasonographic exam followed by the contrast radiologic examination to confirm the diagnosis to an algorithm of a double ultrasonographic investigation[1]. This way, contrast arteriography is not used or used very selectively in our patients. The diagnostic ultrasonography is performed by examiner 1, based on clinical indications. If a stenosis less than 50% is found, the case is discussed and usually referred to medical management and long-term follow-up. In patients with indication for open or endovascular carotid surgery, a second preoperative DUS mapping is performed by examiner 2. In case of contradictions between the two examinations, the patient is again examined by the first examiner or another imaging method (magnetic resonance or CT scan) is ordered. Our surgical team also performs echographic mapping as a means of confirming DUS performed in vascular laboratories elsewhere. Out of the nine cases (<2%) reported as less than 50% carotid stenosis by DUS mapping, six had the initial examination performed elsewhere, two had ulceration of the carotid plaque and one patient had carotid dissection, with a flap.

An algorithm based in two ultrasonographic studies – one for diagnosis and other for preoperative mapping – reduces costs in 70 to 90%, compared to radiologic or magnetic resonance imaging. The latter methods are more expensive and sometimes less reliable for planning the details of the surgical procedure. The approach, the length and location of the incision for endarterectomy may be efficiently planned using ultrasonographic mapping alone[5].

In summary, ultrasonography is fundamental for the diagnosis of carotid stenosis. CT scan or MRI may be performed as a means of confirming degree of stenosis grade or for a thorough evaluation of a symptomatic patient[21,22]. Our experience shows that ultrasonographic mapping may replace these expensive methods and provide consistent data for open or endovascular surgical planning.

One of the aims of this study is to avoid conjoined analysis of subgroups that are better analyzed separately. For instance, gender subgroups should be evaluated separately.

Data from the literature have shown that even though the prevalence of significant stenosis did not depend on the patient's gender[8], restenosis after endarterectomy with partial inversion technique was more frequent in

females[8]. Greater diameters among men were expected and confirmed[23,24]. The length of stay in the hospital was shorter in men compared to women[12]. Blood flow velocity in the carotid artery may also differ between genders[13].

Justification for the selection of variables was as follows: carotid stenosis diameter percentage may not be a strictly scientific variable, for a carotid stenosis with a circular lumen is rare. This variable, however, is used in medical practice, and it has been used in the classic randomized trials that have confirmed the value of surgical carotid treatment. Plaque extension helps planning the incision for endarterectomy and selecting the appropriate devices for endovascular treatment. Previous knowledge of the common and internal carotid diameters prepare the surgical team for problems associated with small caliber vessels – specially in women – and helps planning endovascular treatment, including placement of filters and selection of balloon catheters and stents. The distance from the carotid plaque to the ear lobe helps in the choice of incision site and calls the surgeon's attention to a potentially high bifurcation, with its attendant difficulties of exposure of the segment to be treated.

This study has shown gender differences in degree of stenosis (percentage), carotid plaque extension, carotid artery diameter, and anatomic location of the plaque and the carotid bifurcation. Men present a higher prevalence of critical stenosis, plaques longer than 3 cm and greater distance between the plaque and the ear lobe. A carotid bifurcation high up in the neck was particularly important to identify, for it is associated with intraoperative technical difficulties. A suggestion could be made for screening males earlier than usual. Even though gender differences do exist, , further studies are necessary those men and women that do not fit the usual patterns.

We concluded that non invasive ultrasonographic imaging of the extracranial carotid arteries' anatomy show significant differences between males and females. These findings emphasize reinforce that a pre-treatment protocol should include information on individual anatomic differences that might contribute to the efficiency of open and endovascular procedures.

References

1. Sandri JL. Endarterectomia carotídea somente com duplex. In: Nectoux Filho JL, Salles Cunha S, Paglioli AS, de Souza GG, Pereira AH (editores). Ultra-sonografia vascular. Rio de Janeiro: Revinter; 2000, p. 71-5.
2. Ascher E, Markevich N, Kallakuri S, et al. Intraoperative carotid artery duplex scanning in a modern series of 650 consecutive primary endarterectomy procedures. J Vasc Surg. 2004;39(2):416-20.
3. Salles-Cunha SX, Ascher E, Hingorani AP, et al. Effect of ultrasonography in the assessment of carotid artery stenosis. Vascular. 2005;13(1):28-33.
4. Ascher E, Marks NA, Schutzer RW, et al. Duplex-assisted internal carotid artery balloon angioplasty and stent placement: a novel approach to minimize or eliminate the use of contrast material. J Vasc Surg. 2005;41(3):409-15.
5. Ascher E, Hingorani A, Marks N, et al. Mini skin incision for carotid endarterectomy (CEA): a new and safe alternative to the standard approach. J Vasc Surg. 2005;42(6):1089-93.
6. Menezes FH, Luccas GC, Matsui IA, et al. Avaliação através da ultra-sonografia duplex da medida de reestenose da carótida interna dos pacientes submetidos à endarterectomia aberta da bifurcação carotídea, com eversão parcial da carótida interna. J Vasc Bras. 2005;4(1):47-54.
7. Ascher E, Hingorani AP, Marks N. Duplex-assisted internal carotid artery balloon angioplasty and stent placement. Perspect Vasc Surg Endovasc Ther. 2007;19(1):41-7.
8. Freitas P, Piccinato CE, Martins WP, et al. Aterosclerose carotídea avaliada pelo eco-dopppler: associação com fatores de risco e doenças arteriais sistêmicas. J Vasc Bras. 2008;7(4):298-307.
9. Blackshear Junior WM, Connar RG. Carotid endarterectomy without angiography. J Cardiovasc Surg (Torino). 1982; 23(6):477-82.
10. Chiesa R, Melissano G, Castellano R, et al. Carotid endarterectomy: experience in 5425 cases. Ann Vasc Surg. 2004;18(5):527-34.
11. Pan XM, Saloner D, Reilly IM, et al. Assessment of carotid artery stenosis by ultrasonography, conventional angiography, and magnetic resonance angiography: correlation with ex vivo measurement of plaque stenosis. J Vasc Surg. 1995;21(1):82-9.
12. Hernandez N, Salles-Cunha SX, Daoud YA, et al. Factors related to short length of stay after carotid endarterectomy. Vasc Endovascular Surg. 2002;36(6):425-37.
13. Comerota AJ, Salles-Cunha SX, Daoud Y, et al. Gender differences in blood velocities across carotid stenoses. J Vasc Surg. 2004;40(5):939-44.
14. Ascher E, Markevich N, Hingorani A, et al. Pseudo-occlusions of the internal carotid artery: a rationale for treatment on the basis of a modified carotid duplex scan protocol. J Vasc Surg. 2002;35(2):340-5.
15. Beebe HG, Salles-Cunha SX, Scissons RP, et al. Carotid arterial ultrasound scan imaging: A direct approach to stenosis measurement. J Vasc Surg. 1999;29(5):838-44.
16. Endarterectomy for asymptomatic carotid artery stenosis. JAMA. 1995;273(18):1421-8.
17. Hobson RW 2nd, Weiss DG. Fields WS, et al. Efficacy of carotid endarterectomy for asymptomatic carotid stenosis. The Veterans Affairs Cooperative Study Group. N Engl J Med. 1993; 328:221-7.
18. Wardlaw JM, Stevenson MD, Chappell F, et al. Carotid artery imaging for secondary stroke prevention: both imaging modality and rapid access to imaging are important. Stroke. 2009;40(11):3511-7.
19. Hashimoto H, Tagaya M, Niki H, et al. Computer-assisted analysis of heterogeneity on B-mode imaging predicts instability of asymptomatic carotid plaque. Cerebrovasc Dis. 2009;28(4):357-64.

20. Biasi G, Froio A, Dietrich EB et al. Carotid plaque echolucency increases the risk of stroke in carotid stenting: the Imaging in Carotid Angioplasty and Risk of Stroke (ICAROS) study. Circulation 2004;110(6):756-62.

21. Roffi M, Lüshcer TF. Management of patients with carotid artery stenosis. Herz. 2008;33(7):490-7.

22. Lanzino G, Tallarita T, Rabinstein AA. Internal carotid artery stenosis: natural history and management. Semin Neurol. 2010;30(5):518-27

23. Kreiza J, Arkuszewski M, Kasner SE, et al. Carotid artery diameter in men and women and the relation to body and neck size. Stroke. 2006;37(4):1103-5.

24. den Hartog AG, Algra A, Moll FL, et al. Mechanisms of gender-related outcome differences after carotid endarterectomy. J Vasc Surg. 2010;52(4):1062-71.

Correspondence
Sandra Maria Pontes
Rua José Teixeira, 290 – Praia do Canto
CEP 29055-310 – Vitória (ES), Brasil
E-mail: sandra@angiolabvitoria.com.br

Author's contribution
Conception and design: SMP, FSB, JLS, CMJ
Analysis and interpretation: SMP, FSB, LHR, MATA, JLS, CMJ, DPN, SXSC
Data collection: SMP, FSB, LHR, MATA, JLS, CMJ, DPN
Writing the article: SMP, FSB, SXSC
Critical revision of the article: SMP, SXSC
Final approval of the article*: SMP, FSB, LHR, MATA, JLS, CMJ, DPN, SXSC
Statistical analysis: SXSC
Overall responsibility: SMP
*All authors have read and approved of the final version of the article submitted to J Vasc Bras.