行政院國家科學委員會補助專題研究計畫成果報告

※※※※※※※※※※※※※※※※※※※※※※※※※※

※ 頸動脈支架放置術前後之顱內外血流狀態之評估 ※

※ (Carotid and Cerebral Hemodynamics ※

※ before and after stenting of carotid artery stenosis) ※

※※※※※※※※※※※※※※※※※※※※※※※※※※

計畫類別：☒個別型計畫　□整合型計畫

計畫編號：NSC89－2314－B002－124

執行期間：88 年 8 月 1 日至 89 年 7 月 31 日

計畫主持人：葉炳強教授

共同主持人：呂建榮醫師

計畫參與人員：鄭建興　醫師

計畫參與人員：高憲立　醫師

計畫參與人員：廖漢文　醫師

執行單位：台大醫院神經部

中 華 民 國 89 年 10 月 31 日

行政院國家科學委員會專題研究計畫成果報告

NSC Project Reports

計畫編號：NSC89－2314－B002－124

執行期間：88 年 8 月 1 日至 89 年 7 月 31 日

計畫主持人：葉炳強教授　　執行機構及單位名稱：台大醫院神經部

共同主持人：呂建榮醫師　　執行機構及單位名稱：台大醫院神經部

計畫參與人員：鄭建興 醫師　執行機構及單位名稱：台大醫院神經部

計畫參與人員：高憲立 醫師　執行機構及單位名稱：台大醫院內科部

計畫參與人員：廖漢文 醫師　執行機構及單位名稱：台大醫院影像醫學部

一、中文摘要

本研究共收集33位罹患嚴重的內頸動脈狹窄的病人，其中3位病人兩側內頸動脈皆接受支架放置術，所以共有36條嚴重狹窄的內頸動脈放置支架。我們利用超音波來評估支架放置之術前及術後之血流變化情形。結果發現，在術前的亂流皆可回復成正常血流型式。內頸動脈的直徑從術前平均是3.02± 0.92 mm顯著增加至3.94 ± 0.85 mm。截面積改變的情況比較不明顯，內頸動脈的血流速度也有明顯下降，在術前的內頸動脈之最大速度是2.39± 1.04 m/sec，而術後明顯降至0.66± 0.26 m，內頸動脈與總頸動脈的速度比也顯著下降。然而，椎動脈的血流量則無明顯變化，根據本研究的結果，超音波不但可以評估放置支架後的變化，而我們使用的這些參數，亦可以有效評估其血流動力方面之變化。

關鍵詞：內頸動脈、支架放置術、超音波

English Abstract

Background and purpose: Stenting has been an alternative treatment for patients with internal carotid artery (ICA) stenosis. Color-coded duplex sonography (CDS) is not only able to accurately measure stenosis, also convenient for follow-up of these patients. The purpose of this study was to evaluate the hemodynamics by means of CDS before and after ICA stenting.

Methods: A total of 33 patients (6 women, 27 men, average age of 73.2 years) with severe ICA stenosis were included. Three patients received bilateral ICA stenting. A total of 36 ICAs were stented. CDS was performed before and after stenting in all patients. Some CDS parameters were applied to evaluate the severity of the ICA stenosis before and after stenting. Included were the ICA flow pattern, the ICA peak systolic velocity, ICA to common carotid artery (CCA) velocity ratio, the residual diameter of the ICA, the residual area of the ICA, the flow direction of the ophthalmic artery, and the total flow amount of both vertebral arteries. The CDS parameters before and after ICA stenting were compared.

Results: Of these CDS parameters applied to evaluate the effect of stenting on ICA stenosis, the ICA flow pattern, residual diameter, peak systolic velocity, and ICA to CCA velocity ratio were altered significantly. Recovery of the turbulent flow pattern to the laminar flow pattern was observed in nearly all ICAs (35 of 36) after stenting. The mean residual diameter of the ICA was increased from the pre-stenting (3.02±0.92 mm) to the post-stenting (3.94±0.85) significantly, but the area reduction change was borderline significance. The ICA peak systolic velocity (pre-stenting, 2.39±1.04 m/sec; post-stenting, 0.66±0.26 m/sec; $p<0.0005$) and the ICA to CCA velocity ratio (pre-stenting, 4.94±3.28; post-stenting, 1.02±0.43 m/sec; $p<0.0005$) were decreased significantly. The change of the vertebral arteries flow amount after ICA stenting was not prominent.

Conclusions: According to this study, CDS was able to clearly demonstrate the hemodynamic changes before and after ICA stenting. The CDS parameters of the ICA flow pattern, ICA residual diameter, ICA peak systolic velocity, and ICA to CCA velocity ratio may be suitable for evaluating the effect of stenting on the hemodynamics of the stenotic ICA.
Key words: carotid arteries • stent • ultrasonics

Subjects and Methods

A total of 33 patients (6 women and 27 men; average age, 73.2 years; age range, 61 to 86 years) with severe ICA stenosis were included in this study. These patients were diagnosed and treated with angioplasty and carotid stenting at the National Taiwan University Hospital. CDS was applied to evaluate the hemodynamic status before and after ICA stenting. For better understanding the acute hemodynamic effect of ICA stenting, the period between stenting procedure and the first post-operative sonographic examination must not be more than 60 days. The socio-demographics, clinical manifestations, and the results of laboratory examinations were all recorded and analyzed. The severity of ICA stenosis was judged by both CDS and carotid angiography. In CDS, severe stenosis was defined as the peak systolic velocity of the ICA more than 1.25 m/sec or reduced peak systolic velocity with high resistant trickle flow[7]. Angiographically, severe stenosis was defined as the diameter stenosis was more than 50%. Both symptomatic and asymptomatic severe ICA stenosis were included in this study. The symptomatic severe ICA stenosis was defined as patients having TIA or stroke within prior 120 days and ispilateral ICA stenosis. The diagnosis of stroke and TIA and the method of documentation of stroke and vascular risk factors were described in the prior report [8,9].

The CDS parameters for evaluation of the hemodynamics before and after ICA stenting included the followings: (1) the color flow pattern of the ICA (turbulent or laminar flow); (2) the flow direction of the ophthalmic artery; (3) the residual diameter of the ICA; (4) the cross-sectional area of the ICA; (5) the residual cross-sectional area of the ICA; (6) the area reduction of the ICA calculated from (4) and (5); (7) the peak systolic and end-diastolic velocities of the stenotic ICA; (8) the ICA to CCA systolic flow velocity ratio; (9) resistivity index of the ICA; (10) the flow amount of the ICA, and (11) the total flow of vertebral arteries were all measured. A paired t-test was used to compare the CDS parameter before and after ICA stenting.

Results

Demographic and clinical characteristics

In the 33 patients, a total of 36 internal carotid arteries were treated during 35 procedures. Nineteen patients had prior stroke or TIA among whom 11 patients fulfilled the criteria of symptomatic severe ICA stenosis. Only 17 patients underwent duplex examinations of peripheral arteries and peripheral artery occlusive disease was diagnosed in 12 of them. Three patients received bilateral stenting procedure: two patients were asymptomatic, and the other one patient was symptomatic in one ICA and asymptomatic in the other artery. In other words, in these 36 stenting ICAs, 11 ICAs were symptomatic and 25 arteries were asymptomatic. One asymptomatic patient had contralateral ICA occlusion. Two patients had ever receive irradiation therapy on the head/neck for nasopharyngeal carcinoma: one patient was symptomatic ICA stenosis and the other patient was asymptomatic. One asymptomatic patient had prior balloon angioplasty but had restenosis of ICA so that accepted carotid stenting.

Quantitative analysis by CDS

The mean diameter of these stenotic ICAs significantly increased from 3.03±0.92 mm to 3.94±0.85 mm. The mean peak systolic velocity significantly decreased from 238.9±104.4 cm/sec to 66.1±25.6 cm/sec. The mean ICA/CCA ratio also significantly decreased from 4.94±3.28 to1.02±0.43. The change of area reduction of stenotic ICA was less significant.

Total flow of vertrbral arteries did not

significantly change after carotid stenting.

Qualitative analysis by CDS

There was significant change of flow pattern. Before stenting, turbulent flow was noted in 35 vessels. Only one ICA did not show turbulent flow because of coexistence of distal stenosis. After stenting, the flow pattern of all these 35 stenotic ICA returned to laminar flow. The flow direction of ophthalmic artery ipsilateral to stenting was examined in 29 arteries and the reversed flow direction was noted in 11 ophthalmic arteries before carotid stenting. Six of them returned to normal flow direction after stenting. The other five ophthalmic arteries with reversed flow direction were not rechecked again after stenting

Discussion

Stent may be clearly identified by CDS. The network structure of the Wallstent is hyperechoic in comparison with the background tissue. The Wallstent may not obscure the outline of the post-stenting ICA because of no production of the acoustic shadow. These two factors make it easy to see the result of stenting. The absolute diameter of the post-stenting artery may be exactly measured. The whole stent may be examined from one end to the other to see whether nor not the plaque is totally and smoothly paved by the stent. In this context, CDS is a useful tool to identify a successful stenting no less than angiography.

This duplex study clearly shows the effects of stenting on hemodynamics of ICA. Before stenting, the severity of ICA stenosis was evaluated by ultrasonography whose direct evidences include the appearance of turbulent flow, decreased diameter of artery and increased flow velocity. After stenting, these sonongraphic features were all changed. The turbulent flow returned to laminar flow. This qualitative change of flow pattern suggested that the previous stenotic artery had been dilated after ICA stenting.

CDS is able to provide quantative analysis of severity of stenotic artery. With B-mode imaging, the degree of stenosis was assessed by measuring both diameter and area reduction. The absolute diameter was significantly increased after stenting. However, the decrease in area reduction was less significant. This was because of concomitant dilation of both lumen and outer wall of the artery after stenting (Fig 2) so that the change of area reduction was less significant in spite of significant change of absolute diameter.

Decrease in pre-stenting velocity also suggested the reduction of stenosis. Both the peak systolic velocity and ICA/CCA ratio were significantly decreased after ICA stenting. In this study we did not compare the difference between these two parameters.

It was virtually impossible to calculate the flow volume in the presence of turbulent flow]. Measurement may be taken distal to the site of the stenotic lesion, which was inconsistently performed in this study though. Normalization of flow direction of the ophthalmic artery may suggest the increase in flow volume of the post-stenting ICA. Eleven patients had reverse flow direction of ophthalmic artery which was an indirect sign of severe ICA stenosis. Six of them returned the reverse flow to normal direction. Normalization of reverse flow also provided a qualitative evidence of reduction of stenosis. The ophthalmic flow was not rechecked in the other 5 patients with pre-stenting reverse ophthalmic flow. After stenting, both the recovery of laminar flow pattern and the clearly shown diameter of the stented ICA make it easier to calculation of the flow volume. This may be a useful sonographic parameter for follow-up.

It is also interesting to observe the influence of ICA stenting on hemodynamics of posterior circulation. As increase in the amount of the posterior flow may be observed when significant stenosis occurred in the anterior circulation, reduce in the posterior flow was expected after ICA stenting. However, in this study the total flow of vertebral arteries was not significantly changed after ICA stenting. Some factors may be attributed to this non-significant difference, including the patency of circle of Willis, the blood pressure at that time and health of vertebrobasilar arteries.

記劃結果自評

In conclusion, the presence of stent does not affect the ability of ECDS to perform an ultrasound examination. The CDS clearly showed the direct effects of stenting: the increase in absolute diameter significantly decreased the peak systolic velocity of the ICA as well as increased the flow volume that may be suggested by the normalization of the previously reversed ophthalmic flow. According to the results of this short-term observation, the parameters that were used in this study may be useful for the long-term follow-up evaluation of carotid stenting.

References:

1. North American Symptomatic Carotid Endarterectomy Trial Collaboration. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. N Engl J Med. 1991;325:445-453.
2. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectony for asymptomatic carotid artery stenosis. JAMA. 1995;273:1421-1428.
3. American Heart Association Science Advisory. Carotid stenting and angioplasty. A statement for healthcare professionals from the councils on cardiovascular radiology, stroke, cardio-thoracic and vascular surgery, epidemiology and prevention, and clinical cardiology, American Heart Association. Stroke. 1998; 29:336-348.
4. Major stroke ongoing trial: International carotid stenting study (ICSS). Stroke. 2000;31:1474-1480.
5. Moneta GL, Edwards JM, Chitwood RW, et al. Correlation of North American symptomatic carotid endarterectomy trial (NASCET) angiographic definition of 70% to 99% internal carotid artery stenosis with duplex scanning. J Vasc Surg. 1993;17:152-159.
6. De Bray JM, Glatt B. Quantification of atheromatous stenosis in the extracranial internal carotid carotid artery. Cerebrovasc Dis. 1995;5:414-426.
7. Jeng JS, Chung MY, Yip PK, Hwang BS, Chang YC. Extracranial carotid atherosclerosis and vascular risk factors in different types of ischemic stroke in Taiwan. Stroke. 1994;25:1989-1993.
8. Jeng JS, Lee TK, Chang YC, Huang ZS, Ng SK, Chen RC, Yip PK. Subtypes and case-fatality of stroke: A hospital-based stroke registry in Taiwan (SCAN-IV). J Neurol Sci. 1998;156:220-226.
9. Yip PK, Jeng JS, Lee TK, Chang YC, Huang ZS, Ng SK, Chen RC. Subtypes of ischemic stroke: A hospital-based stroke registry in Taiwan (SCAN-IV). Stroke. 1997;28:2507-2512.
10. Eicke BM, Tegeler CH. Ultrasonic quantification of blood flow volume. In: Tegeler CH, Babikian VL, Gomez CR, eds. Neurosonology. St. Louis, Missouri: Mosby, 1996:101-110.
11. Polak JF. Duplex sonography: can it be used to evaluate carotid artery stents? Radiology. 1997;205:649-650.
12. Robbin ML, Lockhart ME, Weber TM, et al. Carotid artery stenosis: early and intermediate follow-up with Doppler US. Radiology. 1997;205:748-756.