# Stroke Prevention By Carotid Endarterectomy

**H Lau**, FRCS(Edin), FCS(HK), MMed(Surg)(Singapore)
**S W K Cheng**,* FRCS(Edin), FACS, MS, FHKAM
Division of Vascular Surgery
Department of Surgery
Queen Mary Hospital
The University of Hong Kong

## Summary

*Cerebrovascular disease is the third leading cause of death in Hong Kong and stroke is a major cause of disability in the elderly. With increased life span, rehabilitation and care of patients with disabling stroke has become a substantial economic burden to the society and family. Prevention of stroke by carotid endarterectomy is definitely more cost-effective than treatment of stroke. Prospective randomized trials in North America and Europe have proven the benefit of carotid endarterectomy in symptomatic patients with severe carotid stenosis. The diagnosis of carotid stenosis can be easily confirmed by a duplex scan performed in experienced hands. With increased awareness of this condition, early identification of at risk patients with referral to a tertiary centre for consideration of carotid endarterectomy is able to reduce the risk of future stroke or death.* (*HK Pract* 1998;20:484-490)

## 摘要

心血管疾病是本港第三大死因，而中風更是導致年老人殘疾的主要原因。隨著壽命延長，中風後殘疾護理和復康治療已成為社會及家庭的經濟沉重負擔。採用頸動脈內膜切除術預防中風遠較治療中風更為經濟。北美及歐洲前瞻性隨機試驗證實手術對有症狀的嚴重頸動脈狹窄患者有效。現在有經驗的檢查者使用多普勒擔當 duplex scan 檢查，很容易診斷出頸動脈狹窄。醫生應提高警覺，儘早診療和轉介有危險的病人，施行頸動脈內膜切除術，可以減少中風及死亡病例。

## Introduction

Carotid endarterectomy was once the most common vascular procedure in the USA in the 1980s.[1-2] However, concern for post-operative morbidity and mortality of this prophylactic procedure, particularly the risks of stroke and death, led to scepticism of its benefit. The quest for evidence-based medicine then led to a number of controlled trials of carotid endarterectomy in North America and Europe. The North American Symptomatic Carotid Endarterectomy Trial (NASCET), comparing best medical treatment and carotid endarterectomy in symptomatic patients with critical (> 70%) carotid stenosis, demonstrated that 26% of medically treated patients (n=331) had a disabling stroke over 24 months, the stroke rate was 9% in the surgically treated group (n = 328).[3] An absolute risk reduction of 17% was observed. The trial was terminated early in patients with symptomatic high grade stenosis in 1991 because of the strong evidence of the benefit of carotid

* ***Address for correspondence*** : *Dr Stephen Wing-keung Cheng, Associate Professor, Division of Vascular Surgery, Department of Surgery, The University of Hong Kong, Queen Mary Hospital, Hong Kong.*

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endarterectomy. The European Carotid Surgery Trial (ECST), which recruited 3,024 patients, reported similar results to NASCET for symptomatic patients with severe carotid stenosis. When symptomatic carotid stenosis was greater than 80%, the frequency of a major stroke or death at 3 years was 26.5% for the control group without surgery and 14.9% for the surgery group. The immediate risk of surgery is worth trading off against the long-term risk of stroke without surgery.[4]

## Diagnosis

### Presentation

Transient ischaemic attacks (TIAs) and stroke are the two commonest complaints encountered in patients with carotid stenosis.[5] TIA is defined as a transient focal neurologic dysfunction of vascular origin with rapid onset and complete resolution within 24 hours. Neurologic deficits lasting longer than 24 hours but nevertheless resulting in complete resolution are termed reversible ischaemic neurologic deficits (RIND). TIAs encompass two major categories of symptoms based on the arterial territory, either carotid or vertebro-basilar. Carotid territory TIAs refer to those symptoms resulting from ischaemia to the cerebral hemisphere supplied by the terminal branches of internal carotid artery, anterior and middle cerebral arteries. Embolization to the opthalmic branch of anterior cerebral artery gives rise to transient monocular blindness, termed amaurosis fugax, in the ipsilateral eye. Transient hemispheric attacks (**Table 1**) may be associated with transient alterations in speech, motor or sensory disturbance. Vertebro-basilar TIAs are complex and often non-specific.

Clinical evaluation of patients with history of TIAs should include the identification of the affected arterial territory, the number and frequency of episodes, evidence of atherosclerosis and assessment of cardiac disease. Special attention should be paid to identify risk factors such as hypertension, diabetes mellitus, smoking, hyperlipidaemia and cardiac disease, especially atrial fibrillation.

### Physical signs

Physical examination would be normal if there has been complete neurologic resolution. A carotid bruit may be the only positive physical sign in patients with significant carotid stenosis. Its presence should alert the clinician to the possible existence of generalized atherosclerotic arterial occlusive disease. However, the presence of a carotid bruit is not diagnostic of a hemodynamically significant stenosis. The absence of a carotid bruit also does not exclude carotid artery disease as the turbulence created by the narrow stream of blood flow through a critical stenosis may not be strong enough to produce an audible bruit. The intensity of a carotid bruit does not necessarily relate to the degree of stenosis although a high-pitched carotid bruit may indicate a narrower lesion.[6]

### Investigations

Patients who present with carotid territory TIAs or stroke should undergo prompt carotid duplex scan examination. Color Doppler Duplex scan has an accuracy of more than 90% in the detection of carotid stenosis but the reliability of the result depends on the skill and experience of the

**Table 1: Symptoms of carotid territory transient ischaemic attacks**

| | | |
|---|---|---|
| On the ipsilateral side of carotid stenosis | | |
| Amaurosis fugax | – | transient loss or blurring of vision |
| On the contralateral side of carotid stenosis | | |
| Motor | – | clumsiness, weakness, paralysis, hemiplegia |
| Sensory | – | numbness, anesthesia, hemi-paresthesia |
| Speech | – | dysarthria (non-dominant hemisphere), motor or perceptive aphasia (dominant hemisphere) |

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operator (**Figure 1**).[7] Duplex scan incorporates both B-mode ultrasound imaging and Doppler frequency analysis. It allows real-time spatial visualization of blood flow velocity in the carotid arteries and provides both anatomical and physiological evaluation. It permits morphological assessment of the stenotic plaque. Hypo-echogenic plaques represent cholesterol deposition or intraplaque haemorrhage, which may suggest instability of the plaque. Spectral analysis of Doppler frequency allows quantification of blood flow velocity and degree of stenosis. For the detection of a haemodynamic significant stenosis (> 70%), a peak systolic velocity greater than 270 cm/sec and end diastolic velocity greater than 110 cm/sec has a sensitivity of 96% and positive predictive value of 93%.[8] Carotid duplex scan is a useful non-invasive screening method of carotid stenosis.

An arch aortogram with bilateral carotid and vertebral arteriography allows full examination of the extra-cranial vessels from ascending aorta to their terminal intra-cranial branches (**Figure 2**). The status of carotid and vertebral arteries, adequacy of cerebral circulation and cross circulation, and the presence of unusual disease distribution or atypical anatomy can be delineated. Intra-cranial lesions, such as intra-cranial aneurysms and tumors, can also be detected. However, arteriography is not without risks and complications may occur at the puncture site, viz. bleeding, or distally. It carries a 1% risk of stroke and should be performed only if surgery is contemplated. Alternatives to conventional arteriography includes digital subtraction angiography, magnetic resonance imaging or angiography.[9] Recently, some centres have advocated performing carotid endarterectomy on duplex data alone without an arteriogram.[10-11]

Computed tomography of the brain should be performed to detect recent or old cerebral infarcts, or nonvascular intra-cranial lesions. Presentations of intracranial tumors,

**Figure 1: Carotid duplex scan showing a high velocity stenosis in a patient presenting with repeated episodes of transient ischaemic attacks**

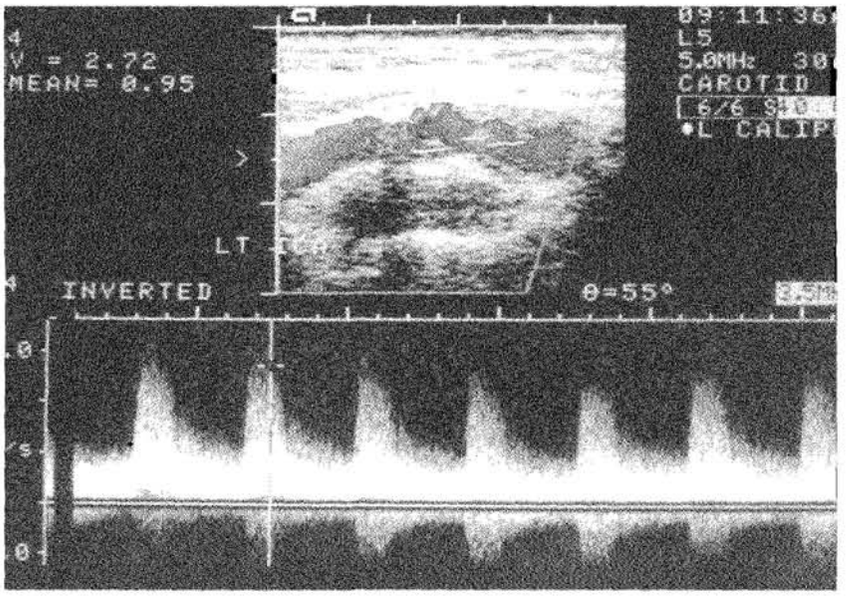
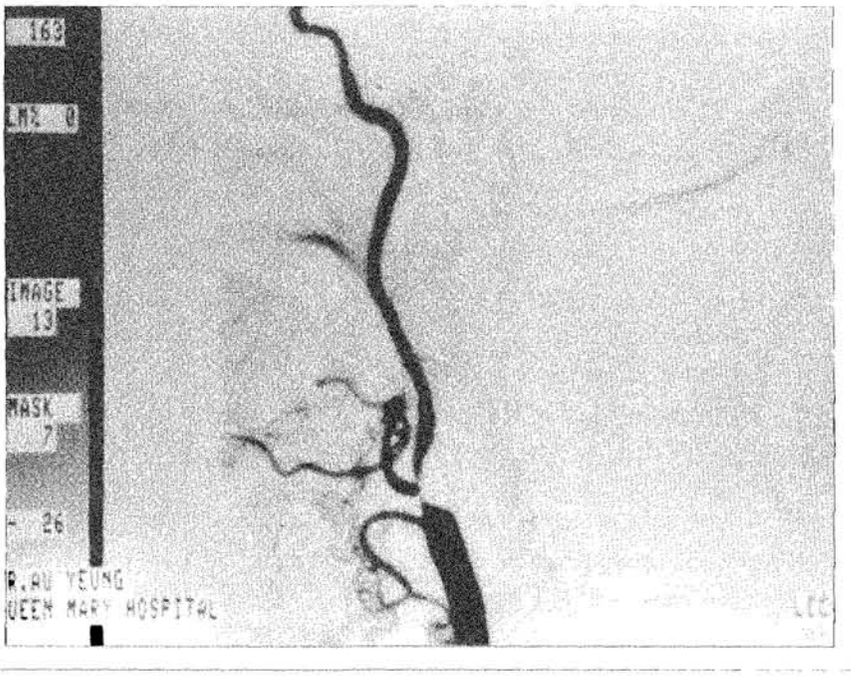



**Figure 2: Carotid arteriography showing the significant stenotic lesion over the origin of the right internal carotid artery**



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subdural hematomas and vascular malformations can all simulate TIAs. **Table 2** shows the differential diagnoses of carotid territory TIAs.[12]

Cardiac evaluation, including transcutaneous or transoesophageal echocardiography, needs to be considered in these patients. Cardiogenic embolism is another major cause of TIAs. Thrombi may form within the heart in the presence of atrial fibrillation, valvular disease and myocardial infarction. In addition, patients with carotid stenosis are often associated with coronary artery occlusive disease.

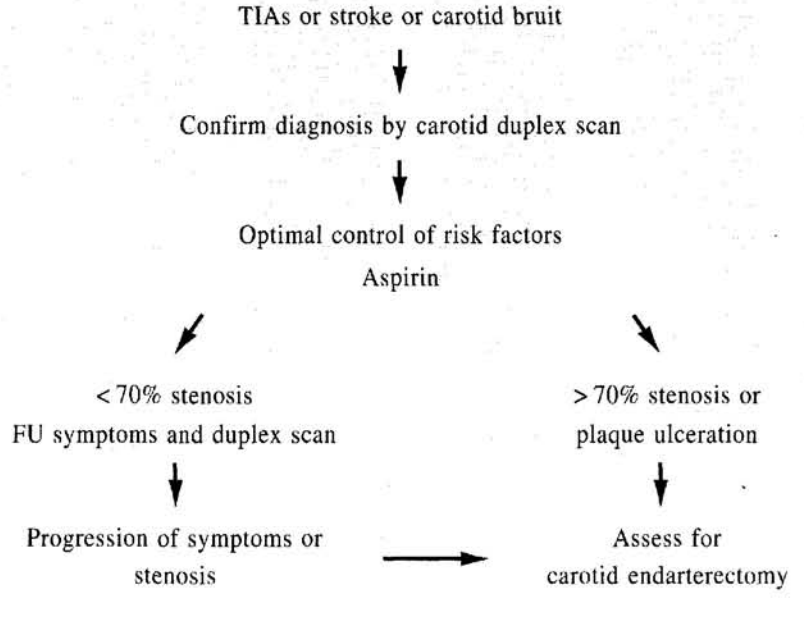
## Management (Figure 3)

Control of risk factors and the use of anti-platelet agents are the mainstays of conservative treatment.[13-14] Optimal control of risk factors, viz. hypertension, diabetes mellitus, hypercholesterolaemia and cessation of smoking, should be achieved in all patients. The optimal dosage of aspirin is unclear but medium dose aspirin (75-325 mg/day) is the most widely tested antiplatelet regimen in the Antiplatelet Trialists' Collaboration overview of 145 randomized trials performed around the world.[15] Ticlopidine is another effective antiplatelet agent but associated with more adverse effects.[16] Antiplatelet therapy has been shown to confer a significant reduction in the risk of non-fatal stroke, myocardial infarction and vascular death in patients at high risk of occlusive vascular disease. The patient should be instructed about other possible symptoms of TIAs, with regular follow up. If the frequency of TIAs increases or the atherosclerotic occlusive lesion becomes haemodynamically significant on follow-up duplex scan examination, surgical intervention should be considered.

**Table 2: Differential diagnoses of carotid territory transient ischaemic attacks**

- Carotid stenosis
- Cardiogenic embolism
  e.g. atrial fibrillation, valvular lesions, infective endocarditis, myocardial infarction, etc.
- Hyperviscosity syndrome
- Small vessel disease
- Hypoglycemia
- Cerebral tumor
- Epilepsy
- Subdural hematoma
- Drop attacks
- Migraine

**Figure 3: Management algorithm for carotid stenosis**




Symptomatic patients with carotid stenosis of 70-99% are now clearly indicated for surgical intervention.[3-4,17] Carotid endarterectomy significantly reduces the mortality rate and increases stroke-free survival. Removal of the stenotic atherosclerotic plaque removes the source of embolization and prevents hypoperfusion. However, the operation carries a small risk of intraoperative stroke or death. The justification of this procedure therefore depends on the balance between the benefit and the risk of this operation. Surgical complication rates must be lower than the accepted

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limits, i.e. a perioperative stroke/ mortality rate of less than 6% for symptomatic patients and 3% for asymptomatic patients.[18-20]

Although the benefit margin seems narrow in asymptomatic patients with significant carotid stenosis, some patients do suffer from disabling stroke or even death without prior warning.[21-23] There is a clear correlation between the risk of stroke and the degree of stenosis.[24] The Asymptomatic Carotid Atherosclerosis Study (ACAS) results suggested that carotid endarterectomy combined with aspirin and risk factor reduction is superior to aspirin and risk factor reduction alone in preventing ipsilateral stroke in asymptomatic patients with diameter stenosis of the carotid artery of 60% or more.[25] The 5-year risk of stroke was 11% for the medical group (n = 834) and 5.1% for the surgical group (n = 825). A relative risk reduction of 53% was observed. Early surgical intervention should also be considered in patients with ulcerative plaque, multiple vessel disease and poor collateral reserve.

**Figure 4: Atherosclerotic carotid plaque removed after carotid endarterectomy**

### Operative technique

Under general anaesthesia, an incision is made along the anterior border of the sternomastoid muscle. After opening the carotid sheath, carotid arteries are gently mobilized and controlled. The vagus nerve and hypoglossal nerve should be identified and safeguarded. An arteriotomy is made over the site of occlusion and a shunt is inserted whenever feasible. Endarterectomy is performed, with great care in completing the endpoint in the internal carotid artery (**Figure 4**). The arteriotomy is closed with continuous 6/O Prolene after removal of shunt. A suction drain is applied and the wound is closed in layers.

Close neuro-observation is necessary to look for neurologic complication after operation. Post-operative stroke or death is the major concern of this procedure. Other early complications include cervical hematoma, blood pressure abnormalities and nerve palsies. Patients should have bimonthly follow up after discharge. Surveillance carotid duplex scan is performed to monitor recurrence of stenosis half yearly.

### Carotid angioplasty and stenting

Carotid angioplasty and stenting has recently been performed as an alternative treatment to carotid endarterectomy. However, the safety and efficacy of carotid angioplasty and stenting have not been well proven. Published results were associated with significantly higher stroke and death rates than those of carotid endarterectomy.[26] Above all, the atherosclerotic plaque, a potential embolic source, is left behind even after successful stenting. Its current application should be limited to clinical trials only until the long term benefits can be resolved by large scale randomized controlled studies.[27]

## In summary

Carotid endarterectomy is a proven means of stroke prevention in symptomatic patients with 70-99% carotid stenosis. Identification of at-risk patients plays an important role in the primary health care. Patients with carotid stenosis should be referred for further assessment and follow up. ■

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## Key messages

1. Recognition of transient ischaemic attacks (TIAs) requires careful attention to patient's history.
2. Carotid territory TIAs have 4 main features: amaurosis fugax, motor, sensory and speech disturbance.
3. The absence of carotid bruit does not exclude the presence of significant carotid stenosis.
4. Duplex scan by an experienced staff is an accurate non-invasive method for diagnosing carotid arterial disease.
5. Carotid endarterectomy by a qualified surgeon with low peri-operative morbidity and mortality is of proven benefit in reducing the incidence of stroke in patients with severe carotid stenosis.

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