Intraluminal Thrombus in the Cerebral Circulation

Implications for Surgical Management

Alastair Buchan, MRCP, FRCPC, Peter Gates, MB, BS, David Pelz, MD, FRCPC, and Henry J.M. Barnett, MD, FRCPC

Thrombi defined as intraluminal filling defects detected by angiography were identified in 30 patients (29 in the carotid system, one in the vertebral artery). Stroke was the presentation ipsilateral to the thrombus in 22 patients (12 had previous transient ischemic attacks), transient ischemic attacks occurred alone in seven cases, and one patient was asymptomatic. Angiography revealed a severe stenosis in association with the thrombus in 23 patients, a moderate stenosis in four patients, and, in the three patients with only minimal stenosis presumably due to atherosclerosis, there was evidence for a coagulopathy. Sixteen of the 30 patients were operated on urgently, 10 within 24 hours of detection of the thrombus. Twelve of these 16 surgical patients were given anticoagulation before surgery. At endarterectomy, thrombus was identified in 11 of the 14 surgical patients in whom the thrombus was accessible; the other two surgical patients had intracranial thrombus only. In this group, four of 11 surgical patients with accessible thrombi suffered perioperative episodes of new or larger infarction. Fourteen of the 30 patients initially received medical management with no complication. Eight of these 14 medical patients had repeat angiography; seven exhibited complete resolution of thrombus, and six of these seven patients subsequently underwent delayed endarterectomy for the stenosis. No thrombus was identified at surgery in any of the six. One of the six delayed surgery patients suffered a perioperative stroke. Although these numbers are small, reflecting the rarity of thrombus demonstrated by angiography, undetected thrombus is often found at endarterectomy. Its presence may increase operative risk. This increased risk could possibly be countered with a preoperative period of anticoagulation and a delay of days or weeks before surgery. (Stroke 1988;19:681–687)

Patients are said to require emergency surgery in the presence of symptoms appropriate to an intraluminal thrombus related to a stenosing lesion. No one has had much experience with this condition, but doubt has been expressed about the basis for this dogmatic statement. We review here our experience with intraluminal thrombus in an attempt to define the clinical presentation, to justify the angiographic diagnosis, and to weigh the benefits and risks of both medical and surgical treatment. The timing of surgery in relation to the presence of thrombus and the risks of arterial occlusion and distal embolization are considered.

Carotid endarterectomy requires a low operative stroke rate if it is to be an effective prophylaxis against stroke. The detection of thrombus may define a high-risk factor for perioperative stroke in patients undergoing carotid endarterectomy.

Subjects and Methods

All cerebral angiography reports between 1975 and 1985 at University Hospital were reviewed for evidence of free intraluminal thrombus within the cerebral circulation. The films of these patients were obtained, and each case was accepted if a filling defect could be seen in two perpendicular planes, with contrast outlining the thrombus. The charts, films, and histologic specimens of these patients were then reviewed for clinical presentation, angiographic findings, treatment, histology, and outcome.

Subjects

Thirty consecutive patients who, on angiography, met the criteria for intraluminal thrombus were evaluated. These represent the total experience at University Hospital over 10 years. There were 24 men and six women, average age 58 years. Fourteen were treated medically (11 with intravenous heparin and three with aspirin) until there was complete (in 13) or incomplete (in one) thrombus resolution; six exhibited complete resolution of thrombus, and six of these seven patients subsequently underwent delayed endarterectomy for the stenosis. No thrombus was identified at surgery in any of the six. One of the six delayed surgery patients suffered a perioperative stroke. Although these numbers are small, reflecting the rarity of thrombus demonstrated by angiography, undetected thrombus is often found at endarterectomy. Its presence may increase operative risk. This increased risk could possibly be countered with a preoperative period of anticoagulation and a delay of days or weeks before surgery.

Clinical Presentation

At presentation, five of the 30 patients had sustained a major stroke, 17 a mild stroke (one a central retinal artery occlusion), seven transient ischemic attacks (TIAs) alone (one a mild contralateral stroke), and one was asymptomatic having suffered a stroke contralateral to the thrombus. Of the 22 patients with a stroke, 12 had suffered previous TIAs.

From the Department of Clinical Neurological Sciences, University of Western Ontario, University Hospital, London, Canada. Address for correspondence: Dr. A.M. Buchan, c/o Dr. H.J.M. Barnett, Robarts Research Institute, PO Box 5015, London, Ontario, Canada N6A 5K8.
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Findings at Angiography

Angiograms were reviewed and the degree of stenosis was classified as severe (>90%), moderate (50–90%), or mild (<50%). Thrombus was identified as an intraluminal filling defect seen in two perpendicular planes, with contrast around the thrombus, and smooth, well-defined margins.

Two symptomatic patients developed new symptoms during angiography (one a stroke, one a TIA). In both patients anticoagulants had been temporarily discontinued for the purpose of angiography.

Angiography revealed that 23 patients had severe stenosis, four moderate stenosis, and three mild stenosis. Eight of the 23 patients with severe stenoses had ulceration in association with stenosis. One patient whose thrombus was distal, in the cavernous carotid artery, had moderate stenosis in the cervical portion but severe tandem stenosis in the petrous portion.

In 26 of the 30 patients the filling defect was seen at the site of stenosis, and in four of these 26 it was seen distally as well as at the plaque site. Four of the 30 patients had thrombus only distally; in one of these four there was severe distal stenosis (Figure 1). Distal thrombus was visualized in the intracranial internal carotid (in six), the middle (in three), or the anterior cerebral arteries (in two). The thrombus was in the carotid circulation in 29 and in the vertebral artery in one patient. The thrombus was categorized as string in 12 (which included all the distal thrombi), irregular and adherent in 11, and as ball thrombus in seven cases.

Results

Medically Treated Thrombus

Treatment was conducted according to the decisions of the attending physicians. Fourteen of the 30 patients were treated medically, 11 with heparin followed by warfarin and three with aspirin (one of the three was changed to warfarin after a TIA). Six of the 14 medical patients underwent delayed endarterectomy and subsequent angiography. In five of the six complete resolution and in the other partial clearing of the thrombus had occurred by the time of the repeat angiogram. The patient with partial clearing did not have surgery for an additional week, and on inspection at surgery no thrombus was found. Two medical patients who did not undergo delayed endarterectomy had angiographic evidence of complete clearing of the
TABLE 2. Patients Treated Surgically at Diagnosis of Intracarotid Thrombus

<table>
<thead>
<tr>
<th>Case/age/sex</th>
<th>Symptom</th>
<th>Stenosis</th>
<th>Additional distal thrombus</th>
<th>Treatment</th>
<th>Presence of thrombus</th>
<th>Operative event</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/71/M</td>
<td>TIA</td>
<td>LICA severe</td>
<td>—</td>
<td>Heparin T, E (90 hr)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>16/57/F</td>
<td>S mild*</td>
<td>RICA severe</td>
<td>—</td>
<td>Heparin T, E (24 hr)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>17/59/M</td>
<td>S mild*</td>
<td>LICA severe</td>
<td>Cavernostring</td>
<td>Heparin E (6 hr)</td>
<td>Distal only</td>
<td></td>
</tr>
<tr>
<td>18/63/M</td>
<td>S mild</td>
<td>RICA severe, ulcer</td>
<td></td>
<td>Heparin E (14 hr)</td>
<td>None found</td>
<td></td>
</tr>
<tr>
<td>19/56/M</td>
<td>TIA</td>
<td>RICA severe</td>
<td></td>
<td>Heparin E (22 hr)</td>
<td>None found</td>
<td>Postoperative TIA</td>
</tr>
<tr>
<td>20/56/M</td>
<td>S mild*</td>
<td>RICA severe, ulcer</td>
<td>Precurastring</td>
<td>Heparin T+E (21 hr)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>21/61/M</td>
<td>S mild*</td>
<td>RICA severe, ulcer</td>
<td>Supraclinostring</td>
<td>Heparin E (30 hr)</td>
<td>Distal only</td>
<td></td>
</tr>
<tr>
<td>22/55/F</td>
<td>TIA</td>
<td>RICA severe</td>
<td></td>
<td>Heparin T+E (3 hr)</td>
<td>+</td>
<td>S mild</td>
</tr>
<tr>
<td>23/74/F</td>
<td>S mild*</td>
<td>LICA severe, ulcer</td>
<td></td>
<td>Heparin T+E (23 hr)</td>
<td>+</td>
<td>S mild</td>
</tr>
<tr>
<td>24/55/M</td>
<td>S mild</td>
<td>LICA severe</td>
<td></td>
<td>Heparin T+E (16 hr)</td>
<td>+</td>
<td>TIA</td>
</tr>
<tr>
<td>25/65/M</td>
<td>Contralateral S (asymptomatic)</td>
<td>RICA severe, ulcer</td>
<td></td>
<td>None T, artery occluded (5 days)</td>
<td>+</td>
<td>Perioperative S major</td>
</tr>
<tr>
<td>26/62/M</td>
<td>S mild*</td>
<td>RICA moderate</td>
<td>R MCA string 1 x 2</td>
<td>Aspirin T+E (5 days)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>27/63/M</td>
<td>S mild</td>
<td>LICA severe</td>
<td></td>
<td>Aspirin E (8 days)</td>
<td>None found</td>
<td></td>
</tr>
<tr>
<td>28/55/M</td>
<td>TIA</td>
<td>LICA mild</td>
<td></td>
<td>Sulfipyrazone T x 2 (2 hr each time)</td>
<td>+</td>
<td>S major</td>
</tr>
<tr>
<td>29/72/M</td>
<td>S mild*</td>
<td>RICA severe, ulcer</td>
<td></td>
<td>None T+E (8 days)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>30/65/M</td>
<td>TIA</td>
<td>LICA severe</td>
<td>Siphon/string</td>
<td>Aspirin T+E (13 days)</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

M, male; F, female; TIA, transient ischemic attack; S, stroke; L, left; R, right; ICA, internal carotid artery; MCA, middle cerebral artery; T, thrombectomy; E, endarterectomy.

* TIA preceding stroke.

Thrombus without recurrent symptoms (Figure 2), and an additional medical patient remaining symptom-free underwent digital intravenous angiography at 150 days, which showed the artery to be patent but did not give clear information about the presence or absence of thrombus.

Of the 14 medical patients, none suffered a stroke, one had a TIA, and one continued to have TIAs. Angiography revealed no new occlusions and no evidence of new embolization. Of the six patients undergoing delayed surgery 14 days to 6 years after resolution of the thrombus, one suffered a fatal stroke following endarterectomy.

Surgically Treated Thrombus

Eleven of the 16 surgical patients were submitted to endarterectomy, with a mean of 27 hours between angiography and surgery. Of these 11, 10 were given intravenous heparin (Table 2). There were no events between arteriography and surgery. Of the remaining five patients, two were pretreated with aspirin, one with aspirin and sulfinpyrazone, and two had no preoperative treatment. The mean time to surgery for these five patients was longer (approximately 5 days), but these 16 patients were grouped together because they were operated on without awaiting the clearance of the luminal thrombus.

Thrombectomy was performed in 11 of the 16 surgical patients; in two of the 16, the thrombus was distal and not retrievable, and in three of the 16 no thrombus was found. Of the three patients in whom no thrombus was found, one had a minor dissection and one had a recanalization; the remaining patient had been on aspirin for 8 days and the thrombus had been on aspirin for 8 days and the thrombus had not resolved without symptoms. None of the three suffered a complication. The perioperative clinical events in the remaining 11 surgical patients consisted of two mild strokes, one TIA, and two major strokes.

Two TIAs occurred in the recovery room, one contralateral to the operated side, related to transient hypotension in a patient in whom no thrombus was found, although there had been an ipsilateral transient delta on intraoperative electroencephalography (EEG). Neither of the two patients with mild stroke had had intraoperative EEGs as the operations had been performed urgently. One awoke with a new deficit, and the other had likely had an extension of the existing stroke. Neither had evidence of hemorrhage on computed tomography (CT). The patient with a new deficit had a follow-up angiogram 8 days postoperatively that showed no evidence of emboli and a patent endarterectomy site. One patient with a major stroke had had the internal carotid artery surgically occluded. Intrav...
operative EEG remained normal. Ten hours later he had transient hemiparesis, which cleared only to be followed by the sudden onset of a dense hemiplegia. This was thought to be embolic; CT ruled out hemorrhage, and subsequent CTs showed a large area of infarction in the middle cerebral distribution. Postoperative angiography revealed distal embolization of thrombus. The other patient with a major stroke had the thrombus removed, and a postoperative angiogram was normal. When his symptoms recurred 9 days later the thrombus had reappeared. The thrombus was removed a second time, without intraoperative EEG, but postoperatively he was drowsy and initially had hemiparesis, which subsequently evolved into hemiplegia. Postoperative angiography revealed total occlusion with distal thrombosis of the carotid artery. No CT was available, but no mass effect was noted on the angiogram to suggest any hemorrhage.

Five of the six events were new. One stroke was likely an extension of a preexisting deficit and occurred intraoperatively. Of the other five events, one was coincident with transient hypotension in the recovery room and no thrombus had been found at operation, three were likely embolic, and the other was shown to be due to progressive thrombosis of the carotid artery. There were no hemorrhages, and all events were ipsilateral to the operative site except for the one TIA. In this case the contralateral carotid artery was already occluded, and both hemispheres were supplied by the operated carotid artery.

A comparison between the medical and surgical groups at the time of presentation and their outcome are summarized in Table 3. Although the surgical patients were less sick (more without stroke) than the medical patients, they sustained more events during treatment.

**Histopathology Observations**

For the medical group no histopathology was available. In the delayed endarterectomy subgroup, as predicted by follow-up angiography, no thrombus was found at surgery and no thrombus was identified by histopathology. In the surgical group, thrombus was removed in 11 patients and identified histopathologically. Two additional surgical patients had distal thrombus that was therefore not amenable to surgical removal, and of the remaining three surgical patients, one had a minor dissection (Case 18), one had recanalization of an occluded artery but no thrombus (Case 19), and one had no thrombus but an 8-day delay on aspirin before surgery (Case 27).

Hemorrhage was identified in the plaque in eight of the 30 cases, ulceration was seen in eight of the 30 cases, and all those with stenosis had complicated atheroma with cholesterol clefts.

**Discussion**

Intraluminal thrombus is not commonly identified. It was seen in only 30 patients in our hospital over a 10-year period during which there were almost 5,000 angiographic studies, of which approximately 2,000 were performed for ischemic cerebrovascular symptoms. Trickle arteriography as described by Hugh^1 may identify more patients with small thrombi who have severe atherosclerotic disease. In the series of Roberson et al^4^ intraluminal thrombus was seen in nine of 1,000 cases, and Kishore et al^5^ found it in four of 133 carotid arterial angiograms. It is possible that if angiography were performed more frequently in the acute aftermath of a stroke, intraluminal thrombus would be seen more commonly.

There is substantial evidence that thromboembolic material in the carotid artery accounts for cerebral symptoms. Because this thrombus has a propensity to embolism and occurs as a prelude to complete arterial occlusion, it is regarded as a threatening finding. It is seen more frequently by histologic examination and gross appearance after surgery than by angiography. Gunning et al^7^ found that thromboembolic material was present in the carotid artery at the time of endarterectomy if the procedure was carried out within 6 weeks of the occurrence of TIA but not if the operation was delayed longer. Another study also analyzed the finding of thrombus in endarterectomy specimens and compared the results with the timing of surgery. Thrombi were found at histologic examination in 66% of 24 patients operated on soon after the onset of symptomatology (<4 weeks) but in only 21% of 28 patients operated on after a delay (>4 weeks).^8^ Our evidence suggests that the appearance of an angiographically detectable intraluminal thrombus occurs most commonly with an ischemic infarction (22 of 30 patients). Twelve of the 22 patients had TIAs prior
to the stroke; in seven patients TIAs alone led to the angiograms.

As in previous reports most patients had thrombi in association with severe atheromatous plaques. The other patients were similar to those previously described, with systemic disease and clot formation related to coagulopathic states.

The angiographic appearance of the thrombus may be elongated, adherent and irregular, or ball-like, and in some cases it may show as a "string sign" in association with a near-occlusion. In the latter there is some nonadherent tailing thrombus extending distal to the severe stenosis into the intracranial portion of the artery.

One concern about the diagnosis of intraluminal thrombus has been the possibility that the radiologic appearances mimic thrombus but actually represent a dissection, flow phenomena, or streaming. In our study we accepted the presence of thrombus radiographically if it was seen in two perpendicular planes. Of the 16 surgically treated patients, two had distal thrombus only. In the remaining 14 with surgically accessible thrombus in the arteriograms, thrombus was detected at surgery in 11. Of the three patients in whom we were not able to confirm thrombus, one had a minor dissection, one had a recanalization, and one with a severe stenosis had an 8-day delay before surgery; it would appear that in this time the thrombus disappeared spontaneously.

### TABLE 3. Comparison of Groups Treated Medically and Surgically During Period of Known Intraluminal Thrombus

<table>
<thead>
<tr>
<th>Presentation</th>
<th>Medical*</th>
<th>Surgical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Mild stroke</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Major stroke</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Medical*</th>
<th>Surgical</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new event</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>New mild stroke</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>New major stroke</td>
<td>1 (following resolution of thrombus at delayed surgery)</td>
<td>2</td>
</tr>
</tbody>
</table>

*Six of 14 submitted to delayed surgery (14 days to 6 years). Angiography indicated clearing of thrombus in all six before surgery.*
A small series of five patients with thrombi in arteries were subjected to repeat angiography: in three thrombi had disappeared and two demonstrated internal carotid artery occlusions. In our series, no occlusions developed in the nine patients who were submitted to repeat angiography (eight conventional and one digital intravenous study), and all but one had no further evidence of thrombus. Possibly the administration of antithrombotic drugs prevented further thrombogenesis while the natural process of fibrinolysis proceeded.

The major question with our series of patients is whether emergency surgical therapy is necessitated by the angiographic finding of intraluminal thrombus. Urgent endarterectomy is questionable: most of these patients have just sustained a stroke, there is the possibility of dislodging thrombus distally into the hemispheres, and surgery aggravates the coagulation cascade that has already been triggered generously.

The treatment assigned in our series of 30 patients with intraluminal thrombus was not predetermined by a protocol, nor was it random, nor were controls assigned deliberately, so our conclusions must be treated with reservation. Nevertheless, it was notable that of the 11 patients who were submitted to early surgery in the presence of an intraluminal thrombus, one had TIA, two had mild persisting ischemic strokes, and two had major persisting ischemic strokes. By contrast those who received medical therapy alone fared better.

Coronary angiography performed in patients with unstable angina has revealed a high incidence of coronary intraluminal thrombus in association with the stenosis. Recent studies with thrombolytic therapy, such as recombinant tissue plasminogen activator (rtPA) in the TIMI Study, for acute myocardial infarction have stimulated its use for acute stroke. Previous streptokinase studies had a relatively high incidence of cerebral hemorrhage partly related to the lack of CT (patients with hemorrhagic strokes could not be excluded) and partly related to the relatively long time between stroke and the administration of streptokinase. rtPA has the advantage that it produces thrombolysis without inducing generalized systemic fibrinolysis. Whether it is more effective in treating stroke remains unknown. Experimental studies have suggested that it should be given early in acute stroke to avoid hemorrhagic complications, and safety studies involving humans are now underway. One such study requires that angiography be performed before and after administration of rtPA during acute stroke (within 8 hours) so additional patients with intraluminal thrombus might be detected. It will be important to see if these thrombi are safely dissolved with rtPA therapy as opposed to the more traditional heparin therapy.

Our observations suggest that the presence of intraluminal thrombus demonstrated angiographically within cerebral vessels may not be a surgical emergency. Prompt institution of full anticoagulation may result in angiographic resolution of the clot with no deterioration in the patient's clinical status. From our series of 30 patients, the evidence suggests that this should be the regimen as a prelude to any surgical intervention.

References


Key Words • carotid endarterectomy • cerebrovascular disorders
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