OPHTHALMODYNAMOMETRY IN CAROTID ARTERY DISEASE

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It is commonly believed that disease of the carotid artery may cause cerebral symptoms, although the way in which these come about is still uncertain.

The pressure changes in the upper part of the carotid artery are thus of great interest and may be approximately followed by measuring the ophthalmic artery pressure. This report is concerned with such measurements in different kinds of carotid disorder.

Method

The Baillart ophthalmodynamometer (dial type) was used and the technique of measurement has been discussed elsewhere (Hartmann, 1949). Readings were taken to the nearest 5g. The instrument was frequently recalibrated and a correction made for the weight of the plunger. The patients sat or lay supine and the systemic blood pressure was measured by the same observer with an arm cuff just before dynamometry. Apart from subconjunctival haemorrhage (one case) and corneal abrasion (one case), there were no complications. Patients with glaucoma, severe myopia, or retinal detachment were not examined.

Results

Normal Subjects.—Ophthalmic artery pressure (OAP) and systemic blood pressure (SBP) were measured in 98 adult subjects without signs or symptoms of cerebral or ocular disease. There were 63 patients in the age group 51 to 70 (106 eyes

Fig. 1.—Relationship of OAP to BP in normal subjects over 50 years. The dotted lines show the 95% confidence limits.

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examined) and 35 patients in the group 14 to 50 (45 eyes examined). The relationship between systemic and ophthalmic pressure in patients over 50 years of age is shown (Fig. 1) and is expressed by the equation OAP g. = (SBP mm. Hg x 0·98) - 26·8 for systolic readings and OAP g. = (SBP mm. Hg x 1·18) - 49·1 for diastolic readings. The slopes of the two regression lines are significantly different (variance ratio 5·3:3; p = < 0·05).

When patients under 50 are considered, the same difference between systolic and diastolic readings is apparent although the total numbers are less.

OAP g. (systolic) = (SBP mm. Hg x 1·00) - 31·2

OAP g. (diastolic) = (SBP mm. Hg x 0·83) - 23·7

Variance ratio 1·25, p = > 0·2.

There is an insignificant difference between the younger and the older group when systolic slopes are compared. The diastolic slopes are different but this is probably due to the inclusion in the older group of a larger number of hypertensive subjects since the slopes do not differ significantly when older patients with diastolic pressures over 100 mm. are excluded. This does not necessarily mean that the relationship OAP/SBP is different in those with hypertension but is due to the small scatter of blood pressure readings below 100 mm.

There was good agreement between the pressures measured in the two eyes of individual patients, the difference, systolic or diastolic, being never more than 10 g. (Fig. 2).

Cerebral Vascular Disease.—Ophthalmic artery pressures were measured in 15 patients recently admitted to hospital with a clinical diagnosis of cerebral thrombosis in whom angiography of the suspected carotid artery showed no abnormality. Ophthalmic artery pressures on both the sound and the suspected side differed by less than 10 g. and both were within normal limits when related to blood pressure (Fig. 3a).

Carotid Stenosis.—Seventeen patients with recent cerebral symptoms, either transient or permanent, in whom angiography showed carotid stenosis were examined in the same way. The majority of OAP...
**Fig. 3.**—Relationship of OAP to BP in cerebral vascular disease (a) normal angiogram, (b) carotid stenosis, (c) carotid occlusion. Closed circles normal side. Open circles suspected side. Dotted lines show 95% confidence limits for normal subject over 50.
Fig. 3(c)

![Graph showing systolic and diastolic blood pressure]

**Fig. 4.** Differences in OAP between two eyes related to the duration of occlusion. In spontaneous cases the onset of occlusion was taken as the date of onset of hemiplegia.
readings were within normal limits (Fig. 3b) and the
difference between the two eyes of individual patients
was less than 10 g. in all but two cases (15 g. and 27 g.
systolic).

Carotid Occlusion.—Twenty-one patients with
complete carotid occlusion were examined. Fourteen
were cases of spontaneous internal carotid occlusion
mostly with recent symptoms and seven had under-
gone common carotid ligation for intracerebral
aneurysm. Ophthalmic systolic readings were
abnormal in all but two cases but about a third of
diastolic readings fell within the normal range
(Fig. 3c). A comparison of pressures in the two
eyes in most cases showed a difference of greater
than 20 g. systolic, the occluded side having the
lower pressure. Diastolic differences were less
marked. In general the greatest pressure differences
were found in patients with very recent symptoms or
immediately after carotid ligation. Longer standing
cases showed less abnormality (Fig. 4) and a series of
measurements on a patient after carotid ligation
showed that the ophthalmic pressure returned to
normal within three months, presumably as a result
of increased collateral supply.

Discussion

Ophthalmodynamometry has many limitations,
since it cannot allow for variations in intracocular
tension, scleral rigidity, or the elasticity of retinal
arteries. The intraocular tension is raised until
blood flow is arrested and at this point it equals the
pressure at the first proximal branch, i.e., the
ophthalmic artery (Duke-Elder, 1926). Results in
normal subjects show that the most important
variant is systemic blood pressure and the relation-
ship between eye and arm blood pressure are
different from systolic and diastolic readings. There
are several possible interpretations for this, but none
is conclusive on the available evidence.

In Bailliart’s hands (Bailliart, 1928) the reading
for ophthalmic diastolic pressure in grams was equal
to the diastolic systemic pressure in mm. Hg and
this was presumably achieved by calculating the
appropriate area of the foot-plate pressing on the.eye.
In the present series the regression line relating
ophthalmic to systemic pressure had a slope which
approached unity but when extrapolated did not
pass through zero but intersected the abscissa at
about 25 mm. The difference between these results
and those of Bailliart and other workers (Bidault,
1931; Streiffe, Audéoud-Naville, and Audéoud,
1937) is probably due to minor variations in
technique as in the arbitrary point taken as the
diastolic level.

Previous reports on the value of ophthalmodyna-

metry in detecting carotid occlusion are confirmed
(Thomas and Petrohelos, 1953; Wood and Toole,
1957; Heyman, Karp, and Bloor, 1957). A difference
in pressure of more than 25 g. between the two eyes
is almost diagnostic and a difference of this order is
more likely to be found in systolic than in diastolic
readings and in recent rather than late cases. The
origin of the internal carotid artery may be explored
on this evidence alone if angiography is not available.
Conversely a small difference in ophthalmic pressure
between the two sides in a proved case of complete
carotid occlusion indicates that the obstruction has
been present for some months and that surgery will
probably be useless.

Milletti (1950) has shown that in cases of carotid
occlusion where routine dynamometry shows no
difference in pressure, compression of the patent
carotid for 30 seconds produces a large fall in both
eyes, more marked on the occluded side. This is too
hazardous to become a routine procedure but compres-
sion for periods of a few seconds may be suf-

ficient for diagnosis (Lowe and Stephens, 1961).

The normal findings in cases of carotid stenosis
show that the flow through the damaged artery and
through the collaterals is sufficient to maintain a
normal pressure in the ophthalmic artery and
probably in the upper part of the internal carotid
(Duke-Elder, 1926). Direct measurement at opera-
tion confirms that in such cases there is only a slight
pressure gradient across a stenosis (Fig. 5). This
does not necessarily imply that blood flow through
the stenosed segment is normal, since a normal
pressure may be found with complete block in the
presence of good collaterals.

Pressure measurements, both direct and indirect,
are of interest in connexion with transient cerebral
ischaemic attacks. These occur in various forms of
cerebral vascular disease but are particularly associated with carotid stenosis. They are commonly thought to be the result of a fall in systemic blood pressure which produces a temporary vascular insufficiency in the territory of a damaged artery (Meyer, Fang, and Denny-Brown, 1954).

Clinical observations have shown this mechanism to operate in some patients (Shanbrom and Levy, 1957; Eastcott, Pickering, and Rob, 1954) but in others transient attacks seem to occur without change in pulse or blood pressure (Alajouanine, Lhermite, and Gautier, 1960). Further, while large falls in blood pressure are frequently produced by treatment in hypertensive patients, many of whom also suffer from occlusive cerebral vascular disease, it is unusual for a focal ischaemic attack to occur (Fazekas, Kleh, and Parrish, 1955). If transient attacks are due to temporary falls of pressure in the carotid territory, and if the dynamometer reflects the pressure changes in the upper part of the artery, it would be expected that patients with a recent carotid occlusion who show a marked fall in ophthalmic pressure would suffer frequently from transient attacks.

In fact transient attacks are very rare after carotid ligation and are more often associated with carotid stenosis, and since there is no reason to suppose that falls in systemic blood pressure occur more frequently in carotid stenosis than occlusion, it seems that factors other than blood pressure may be operating. The observations of Fisher (1959) on a patient during an attack of monocular blindness and the effect of anticoagulant drugs on transient cerebral ischaemia (Siekert and Millikan, 1955) have revived interest in cerebral embolism, and more evidence on this important point is needed.

Summary

Measurements of ophthalmic artery pressure and of systemic blood pressure were made in normal subjects and in patients with carotid stenosis and occlusion. A reduction in ophthalmic pressure was found in recent cases of carotid occlusion but not carotid stenosis. The significance of these findings in regard to the symptoms of carotid disease is discussed.

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REFERENCES