DIRECT MEASUREMENT OF INTRAVASCULAR PRESSURE IN COMPONENTS OF THE CIRCLE OF WILLIS

A CONTRIBUTION TO THE SURGERY OF CONGENITAL CEREBRAL ANEURYSMS AND VASCULAR ANOMALIES OF THE BRAIN*

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SEVERAL METHODS are available for the determination of the resistance to cerebral blood flow across the components of the Circle of Willis. The best known, and oldest in terms of clinical usage, is the Matas test.[4, 5] In this test of cross–hemispheral circulation, the internal or common carotid artery is manually compressed against a transverse process of a cervical vertebra. The onset of vertigo, loss of consciousness or actual neurologic defect, such as hemiparesis, indicates inadequate cross-circulation and represents a positive Matas test. A negative Matas test, that is normal cross–hemispheral circulation, is indicated if the patient, in this preoperative test, fails to show such subjective or objective changes after a ten-minute period of carotid occlusion. When the internal carotid artery is visualized at open arteriography, the test may be facilitated by instrumental occlusion of this efferent vessel. A positive Matas test customarily proves a grossly inadequate cross-circulation, but a normal Matas test does not guarantee freedom from cerebral complications secondary to anoxia following permanent carotid ligation. The concomitant use of electro-encephalography and digital compression of the internal carotid artery has also failed to demonstrate such border-line instances of deficient cross-circulation.[11] The anatomical normality of the anterior part of the Circle of Willis can sometimes be tested during arteriography if the opposite carotid artery be simultaneously compressed. In a variable and unpredictable number of cases, the contrast medium will cross the anterior cerebral–anterior communicating arterial pathway and be visualized in the opposite anterior cerebral artery. Vital dye and nitrous oxide technics for the study of cerebral circulation cannot be fully utilized for the study of resistance in the Circle of Willis and, if applicable, give but a single reading. The procedures available have not been utilized widely by neurosurgeons.

Much of the work to be described stems directly from reports by Sweet and Bennett,[9] Sweet, Sarnoff and Bakay[10] and by Brackett and Mount.[2] The first group of observers recorded accurately the intravascular pressure in the internal carotid artery in the neck when this vessel was occluded temporarily during the procedure of open arteriography. The average of observations upon 26 adults showed that occlusion of the internal carotid artery in the neck caused a drop in systolic pressure to 51 per cent, in pulse pressure to 31 per cent, and the integrated mean pressure to 57 per cent of the original levels. When greater pressure falls to 30 per cent of the original levels were

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encountered, as they were in three cases, inadequate cross-circulation was proved by the onset of cerebral complications in two of these patients following neck ligation. Brackett and Mount have published confirmatory results, using the technic of indwelling carotid catheters. Both groups have emphasized the marked variations in these objective measurements from case to case and have pointed out the importance of individual patient study prior to the application of any standard form of therapy.

Due to the variable neurosurgical problems that may be encountered in patients with formidable vascular lesions of the brain, and to the technical requirements of the apparatus used, relatively few opportunities have presented themselves for an extension of this analysis of intravascular pressure to components of the Circle of Willis. In nine patients with proved congenital cerebral aneurysms and in seven patients with vascular anomalies of the brain and in one other patient undergoing craniotomy, intravascular pressure studies have been done in the neck vessels; in ten of these patients, the analysis of intravascular pressure has been extended to various components of the Circle of Willis, and in particular, to the middle cerebral artery.

TABLE I.—*Systolic Pressure Drops in Percentage in Internal Carotid Artery (Neck) Following Temporary Proximal Occlusion of Indicated Vessels.*

	S.J.	J.W.	L.R.	J.B.*	R.S.	G.J.	R.W.	R.P.	D.C.	E.B.	M.M.	L.J.	J.C.	R.A.	V.W.	J.H.	H.S.
Occlusion, internal carotid	50	28	56	28	56	50	62	33	46	43	79	40	38	..	47	56	62
Occlusion, common carotid	44	30	56	30	43	59	60	32	48	43	79	35	30	52	47	45	60
Occlusion, external—common carotids	..	..	55	..	..	..	..	..	..	..	80	38	..	..	47	57	63
Occlusion, external carotid	..	..	0	0	0	0	0	0	0	0	0	..	..	..	0	0	0

* Mean Pressures.

TABLE II.—*Systolic Pressure Gradient Drops in Percentage in Carotid Arterial Tree Following Temporary Occlusion of Neck and Intracranial Vessels.*

Occlusion	Pressure Reading	S.J.	J.W.	J.B.†	R.W.	R.P.	M.M.	L.J.	R.A.	V.W.	J.H.
Internal carotid neck	Int. carotid, neck	50	28	28	62	33	79	40	..	47	56
	Int. carotid, brain	..	24	29	59	28	84	35	..	47	..
	Middle cerebral	37	*15	34	60	29	**	44	***	48	60
Common carotid neck	Int. carotid, neck	44	..	30	60	..	..	35	52	47	45
	Int. carotid, brain	..	..	..	55	..	..	28	46	56	..
	Middle cerebral	40	..	37	56	..	..	..	45	..	42
Ext. and common carotid neck	Int. carotid, neck	..	..	..	..	..	..	38	..	47	..
	Int. carotid, brain	..	..	..	60	..	..	21	..	..	..
	Middle cerebral	..	..	..	65	..	..		..	..	..
Int. carotid, brain	Int. carotid, brain	..	..	..	..	..	..	..	..	42	..
	Middle cerebral	..	..	..	..	..	..	52	64	42	62

* Reading made after clip ligation of anterior cerebral artery.
** Aneurysm ruptured before reading made.
*** Internal carotid artery not available, readings refer to common carotid.
† Mean pressures.

Method: Patients were selected in the earlier phase of this study who had proved vascular lesions in the non-dominant hemisphere.[1] Since experience has shown the inherent safety of this measuring technic, repetitive tests have been applied to all patients with intracranial vascular lesions during the progress of the operative procedure. After the usual skin preparation, the anterior-superior cervical triangle and the involved hemisphere were draped as a single operative field. The common, internal and

external carotid arteries were exposed in the neck unless an unusually high carotid bifurcation made this unduly difficult. All pressures were obtained with a Sanborn electromanometer through a 27 gauge, 6 cm. needle introduced into the lumen of the vessel and recorded with a Sanborn direct current amplifier-recorder. In the more recent patients of this series, a minute polyethylene catheter was inserted into the proximal portion of the common carotid artery for simultaneous measurement of the systemic blood pressure during neck and intracranial intravascular pressure recordings. In the earlier patients of this series, the systemic blood pressure had been ascertained by the usual arm cuff method. Intravascular pressure falls were measured in the internal carotid artery following temporary occlusion of that vessel, of the common carotid artery, of the external carotid artery and of both external and common carotid arteries.

TABLE III.—*Intravascular Pressure in Internal Carotid Artery Segment Isolated by Intracranial Clip Ligation and Ligation in Continuity in Neck.*

1. G. J.		
Preligation	Pressure in internal carotid artery, neck	102/76
	Pressure in isolated carotid segment	46/44
	Percentage systolic drop	55
2. J. W.		
Preligation	Pressure in internal carotid, neck	114/78
Preligation	Pressure in internal carotid, brain	104/72
	Pressure in isolated carotid segment	60/48
	Percentage systolic drop	52
3. L. J.	Technically unsatisfactory, but decrease in visual acuity to 20/400 from preoperative level of 20/50.	
4. R. P.		
Preligation	Pressure in internal carotid, neck	74/40
	Pressure in internal carotid, brain	84/62
	Pressure in isolated carotid segment	44/40
	Percentage systolic drop	52

As the second phase of the study, formal craniotomy was performed with intracranial exposure of the anterior components of the Circle of Willis on the affected side and with visualization of the vascular disorder. Measurements were taken in sequence from the proximal portion to the most distal portion of the intracranial arterial tree, with pressure gradients being obtained following temporary occlusion with forceps of the proximal arterial segment, either in the neck or intracranially. Following ligation of any part of the arterial tree, if proved indicated by these studies, the residual intravascular pressure was measured distally, with particular attention to that in the middle cerebral artery. In trap ligation for aneurysm of the intrasinus portion of the internal carotid artery, the residual pressure in the blind arterial segment was also determined.

Following withdrawal of the needle, minimal bleeding from the intracerebral vessels was controlled by the pressure of a gelatin foam pledget. None of the patients showed untoward sequelae and in three patients, postmortem review of the vessels showed no post-puncture hemorrhage or thrombosis.

TABLE IV.—*Effect of Temporary Occlusion of Anterior Cerebral Artery Upon Intravascular Pressure in Middle Cerebral Artery.*

			Systolic Percentage Fall
1. L. J.			
Occlude internal carotid, neck	90/66 to	50/42	44
Occlude internal carotid, brain	92/66 to	44/36	52
Occlude anterior cerebral artery	100/70 to	100/70	0
2. V. W.			
Occlude internal carotid, neck	130/82 to	68/56	48
Occlude internal carotid, brain	134/84 to	76/60	42
Occlude anterior cerebral	130/80 to	36/32	72
With anterior cerebral occluded...			
Occlude internal carotid, neck	36/32 to	34/28	74

DISCUSSION

These data represent the results of acute physiologic studies in man and the status of intravascular pressure in various components of the Circle of Willis immediately after temporary proximal occlusion. In postligation studies, the greatest time interval between permanent vascular occlusion and intravascular pressure recording was 30 minutes. The residual intravascular pres-

sure, influenced by ligation and adjusted through collateral circulation, can only be studied in man in exceptional cases, although the intracranial vascular pressure might be inferred through successive neck ligation recordings.

The data found in Table I are, in general, consistent with previously recorded experience gained from temporary occlusion of the internal carotid artery in the neck.[2, 9, 10] When used during the progress of an operation designed to control the source of acute subarachnoid hemorrhage, this repetitive type of pressure recording might be termed an objective Matas test. They indicate, however, an apparent higher incidence of increased cross-resistance at the Circle of Willis. This may be a pure coincidence or may reflect Dandy's finding that anatomical variations in the Circle of Willis are almost twice as frequent in the presence of congenital aneurysms as in those without aneurysms.[3] In but one case, C. J., did temporary occlusion of the common carotid artery cause a greater fall in intravascular pressure in the internal carotid artery than did occlusion of the latter vessel. In most acute recordings, occlusion of the common carotid artery caused pressure recordings that were equal to or less than those obtained through occlusion of the internal carotid artery. Within the limits of the apparatus and recording technics used, occlusion of the external carotid artery alone failed in each case to change intravascular pressure in the internal carotid artery. When the common carotid artery was temporarily occluded and this occlusion was followed by occlusion and release of the external carotid artery, the part played by the external carotid circulation in the maintenance of internal carotid pressure was readily ascertained. These recordings substantiated those obtained by differential occlusion of the common and internal carotid arteries.

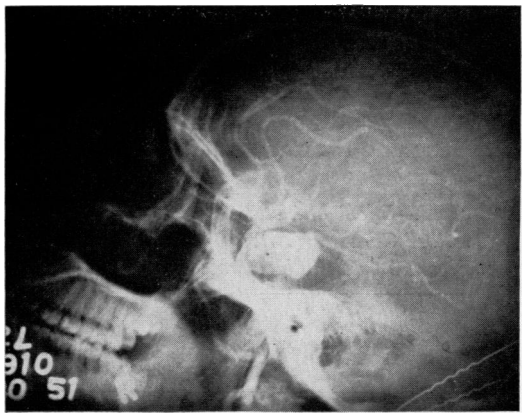

FIG. 1.—Arterial aneurysm of the internal carotid artery, left, within cavernous sinus (Case 1).

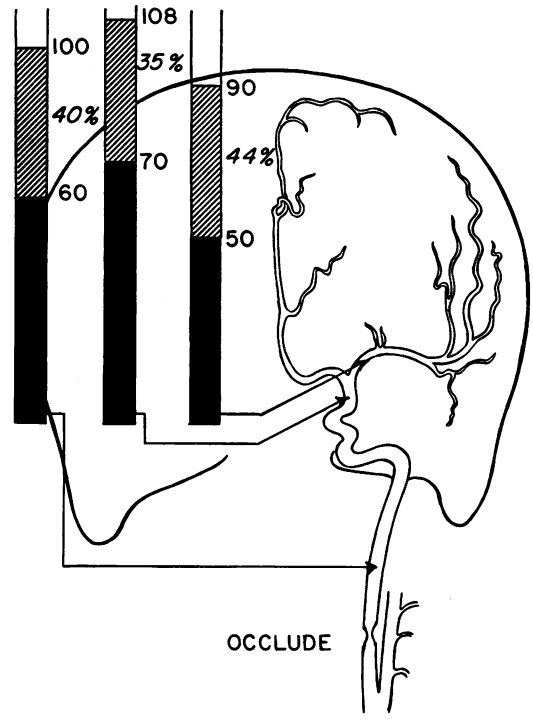

FIG. 2.—Diagramatic representation of intravascular pressure gradient drop in the arterial tree following temporary occlusion of the internal carotid artery in the neck (Case 1).

In Table II, data are presented which extend observations upon intravascular pressure found in the neck vessels to the intracranial portion of the internal carotid artery and to the middle cerebral artery. In any one individual, the intravascular pressure gradient is fairly constant, and seems to be

influenced acutely only by changes in systemic blood pressure. Many more observations will be needed before inexplicable variations such as those noted in L. J. are understood. The recordings in Tables I and II are sufficient, however, to indicate that intravascular pressure readings will define the extent of pressure fall throughout the arterial tree of the internal carotid artery. Some concept of the clinical use of these readings will be illustrated under the heading of Case Reports.

In four cases, some form of trap ligation of an aneurysm of the internal carotid artery formed an isolated arterial segment containing only the ophthalmic artery and perhaps minute arterial branches passing to the optic chiasm. That blindness may follow such a procedure has been recognized, caused perhaps by thrombosis within this closed segment.[6] In one of the two cases of blindness following a trap ligation noted in the Duke Hospital, loss of vision was apparent upon a rapid recovery from anesthesia, suggesting some cause for this complication other than thrombosis. In the one case of this series in which vision was impaired, technical difficulties encountered during recording precluded an accurate study. The finding of a relatively high intravascular pressure in three cases following trap ligation of the internal carotid artery was a relatively unexpected one and this phase of the subject needs further study.

Only two observations were possible upon the influence of occlusion of the anterior cerebral artery upon intravascular pressure in the middle cerebral artery. In the first case, no observable change could be detected. In the second case, it was obvious that permanent occlusion of this large anterior cerebral artery would cause a disastrous fall in pressure; accordingly, therapy was objectively directed toward ligation of the internal carotid artery.

CASE REPORTS

Aneurysm of Internal Carotid Artery Within Cavernous Sinus. Intravascular pressure studies indicated normal cross–hemispheral circulation with a systolic pressure drop of 44 per cent in the middle cerebral artery following internal carotid occlusion. "Trap" ligation of the aneurysm was done without postoperative cerebral complication. The significance of residual pressure in the isolated arterial segment is noted.

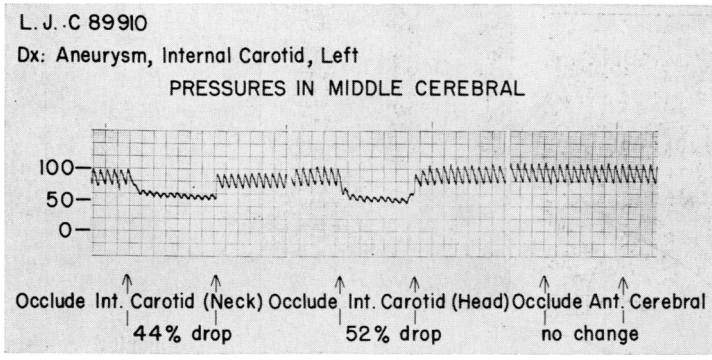

FIG. 3.—Manometric record of intravascular pressure in the middle cerebral artery during temporary occlusion of indicated vessels (Case 1).

Case 1.—L. J., a Negro female, age 30, was admitted to the Duke Hospital on August 30, 1951, with the presenting complaints of diplopia, weakness in the right leg and intermittent headache for the past 9 months. Her illness began abruptly in September, 1949, with severe generalized headache and diplopia. Headache had persisted with periodic exacerbations and there had been slight diminution in visual acuity in the left eye. Weakness in the right lower extremity improved 2 months after the onset of the illness.

The neurologic examination disclosed a sixth nerve paralysis on the left side, slight ptosis of the

left eyelid with normal pupillary reactions, concentric constriction of the left visual field and vision in the O.D. of 20/20 and in the O.S. of 20/50. Roentgenograms of the skull were normal and the electro-encephalogram was reported as within normal limits. A left arteriogram disclosed a massive aneurysm of the left internal carotid artery within the cavernous sinus (Fig. 1). The Matas test was negative.

On September 10, 1951, the carotid vessels on the left side were exposed. A left frontal craniotomy disclosed elevation of the dura over the cavernous sinus, and this region could be collapsed with slight instrumental pressure. Detailed recordings of intravascular pressure were obtained.

		Systolic Drop
I. Pressures in internal carotid (neck)		
1. Occlude common carotid	96/72 to 62/56	35%
2. Occlude internal carotid	100/74 to 60/50	40%
3. Occlude common carotid	114/86 to 80/66	30%
4. With common carotid occluded, occlude external carotid and superior thyroid	80/66 to 72/62	38%
5. Occlude common carotid and superior thyroid	120/90 to 70/60	42%
6. Occlude internal carotid	120/90 to 72/62	41%
II. Pressures in middle cerebral artery		
1. Occlude internal carotid, brain	92/66 to 44/36	52%
2. Occlude internal carotid, neck	90/66 to 50/42	44%

The intravascular pressure recordings in this case might be termed those representative of a normal degree of hemispheral cross-circulation. Similar findings were noted in 11 of the 17 cases in this study. In this instance, the carotid aneurysm was trapped between a clip ligation of the intracranial portion of the internal carotid artery and a double ligation in continuity of the internal carotid artery in the neck. The residual intravascular pressure in the left middle cerebral artery after this procedure was 74/60. There was no evidence of aphasia or hemiparesis during the postoperative period of convalescence. Vision in the left eye was reduced to 20/400 and there was a concentric reduction in vision in the peripheral visual field. The possible significance of this visual loss has been discussed in the consideration of intravascular pressure in the isolated carotid segment.

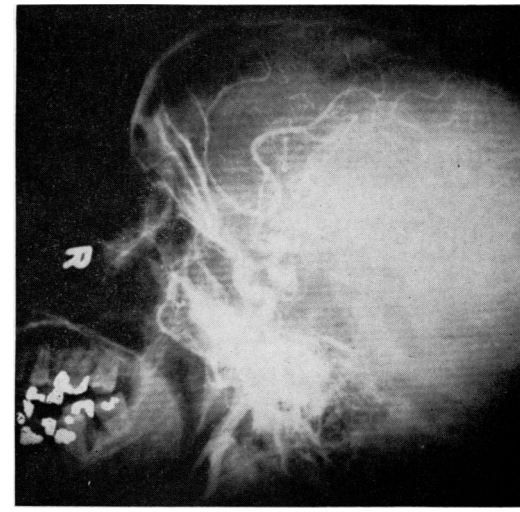

FIG. 4.—Arteriogram of a congenital cerebral aneurysm of the internal carotid artery within the cranial cavity (Case 2).

By comparison, the following two cases illustrate, in the presence of a normal Matas test, objective evidence of inadequate cross-hemispheral blood-flow through direct intravascular pressure measurements of the involved arterial segment.

Case 2.—W. M., a 39-year-old white female was admitted to the Duke Hospital on September 1, 1951, with the classical story of an acute subarachnoid hemorrhage occurring 10 days before admission. Since 1943 she had been studied periodically for a mild hypertension, ranging from 140/80 to 170/90. Fourteen days before admission, she had noted blurring of vision and had herself observed dilatation of the left pupil. Ten days before admission she had been awakened from sleep with an agonizing left retro-orbital and temporal headache, associated with nausea and vomiting and followed by ptosis of the left eyelid and

FIG. 5

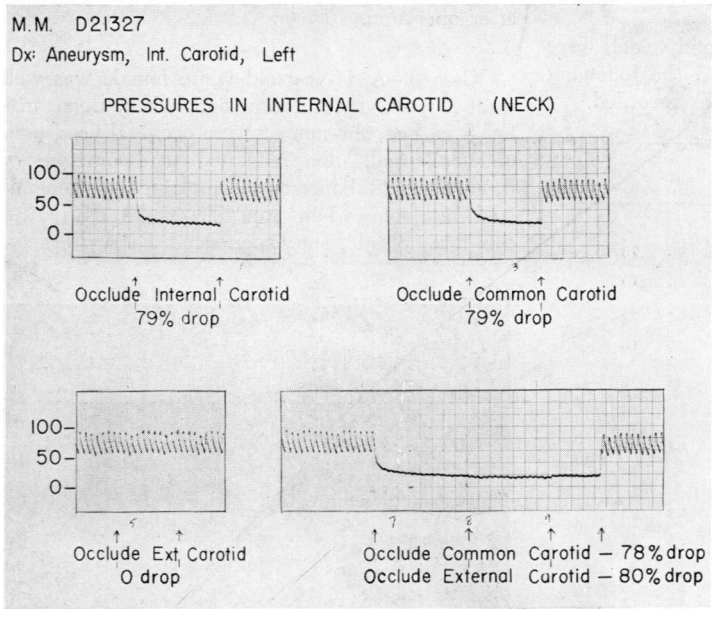

FIG. 5.—Manometric record of extreme fall in intravascular pressure in neck vessels following occlusion of indicated vessels (Case 2).

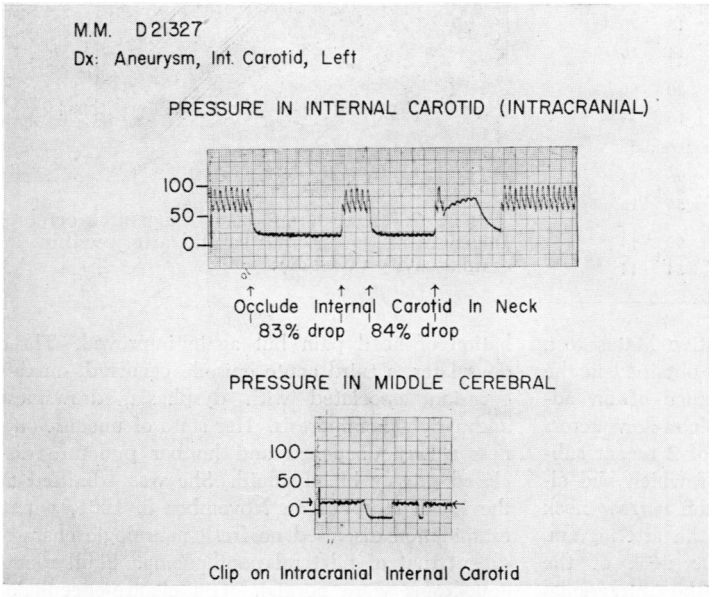

FIG. 6.—Manometric record of intravascular pressure fall in the middle cerebral artery following forced clip ligation of the internal carotid artery intracranially. The artefacts are due to the very low residual pressure.

FIG. 6

diplopia. Lumbar puncture disclosed grossly bloody cerebrospinal fluid.

The neurologic examination upon admission disclosed a moderately ill patient, complaining of severe headache; there was ptosis of the left eyelid, dilatation and fixation of the left pupil and hypalgesia over the first and second divisions of the left trigeminal nerve. The electro-encephalogram and roentgenographic studies of the skull were normal. Thirty hours after admission there was an abrupt increase in head pain and cervical rigidity, the onset of drowsiness and dysphasia and a rise in blood pressure to a level of 220/110. There was but slight evidence of clinical improvement during the next 7 days. A left arteriogram showed an aneurysm of the left internal carotid artery at

its junction with the posterior communicating artery. It appeared to have a very small neck (Fig. 4).

On September 7, 1951, the carotid vessels were exposed in the cervical region and the following intravascular pressure studies were recorded.

		Systolic Drop
I. Pressure in internal carotid, neck		
1. Occlude common carotid	96/60 to 20/16	79%
2. Repeat	94/56 to 20/18	78%
3. Occlude internal carotid	96/60 to 20/16	79%
4. Repeat	94/36 to 20/16	79%
5. Occlude external carotid	92/58 to 92/58	0
6. With common carotid occluded, occlude external carotid	20/18 to 18/14	10%
7. Release external carotid	18/14 to 20/16	
8. Release common carotid	20/16 to 86/54	
II. Pressure readings in internal carotid, intracranial		
1. Occlude internal carotid, neck	96/56 to 16/16	83%
2. Repeat	90/54 to 14/14	84%

In spite of a normal preoperative Matas test, the intravascular pressure readings obtained in the neck vessels were objective evidence of an advanced degree of resistance to blood-flow across the Circle of Willis. The history of 2 recent subarachnoid hemorrhages, the last of which had almost overcome the patient, and the narrow neck of the aneurysm, as disclosed in the arteriogram, suggested an attempt to clip the neck of the aneurysm. Pressure readings in the intracranial portion of the internal carotid artery confirmed the total inadequacy of hemispheral cross-circulation. At this point the aneurysm ruptured and clip isolation of the aneurysm was necessary to control the bleeding point. The residual intravascular pressure in the middle cerebral artery was recorded at 14/14 (Fig. 6). Due to the low pressure, artefacts could not be prevented in the graphic recording of this degree of hypotension, incompatible with normal function in the dominant hemisphere. Autopsy disclosed an infarction of all neural tissue in the vascular domain of the left middle cerebral artery, death occurring 36 hours after operation.

Case 3.—A 45-year-old white female was well until 2 weeks before admission, when, upon arising from bed, she noted severe occipital head pain and collapsed. She remained semi-comatose or drowsy for 24 hours and complained of generalized headache when aroused. Three days after this first episode, she experienced a sharp exacerbation of head pain but again improved. Three days later, a third acute episode occurred, on this occasion associated with dysphasia, drowsiness and a right hemiparesis. Her state of unconsciousness slowly deepened and lumbar puncture disclosed grossly bloody fluid. She was admitted to the Duke Hospital on November 8, 1951, where examination disclosed no fresh neurologic changes except that of bilateral papilledema. Skull roentgenograms were normal. The electro-encephalogram showed a clear-cut slow wave focus in the left frontal lobe. The significance of such changes in patients with acute subarachnoid hemorrhage has been explored in a previous communication.[8] The Matas test was normal. Left arteriography disclosed a large congenital cerebral aneurysm of the internal carotid artery at its point of emergence into the cranial chamber (Fig. 7).

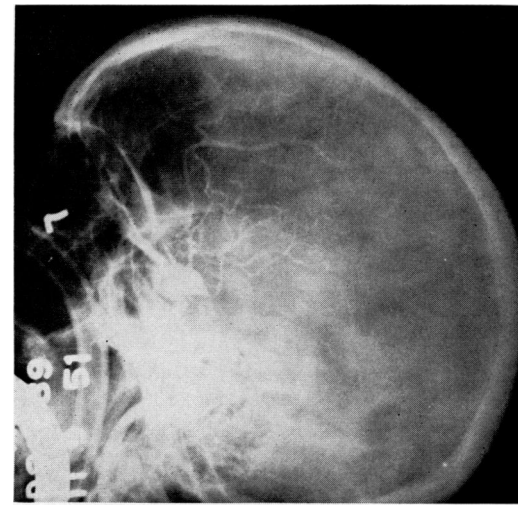

FIG. 7.—Arteriogram of a congenital cerebral aneurysm of the internal carotid artery within the cranial cavity (Case 3).

On November 13, 1951, the left cervical region and the left side of the cranium were prepared as a single operative field. The neck vessels were

exposed and the following intravascular measurements were recorded.

		Percentage Systolic Drop
Pressure in internal carotid, neck		
1. Occlude internal carotid	128/80 to 56/44	56%
2. Repeat. Mean pressure	104/94 to 50/48	51%
3. Occlude common carotid	130/80 to 72/54	45%
4. Repeat. Mean pressure	104/94 to 68/64	33%
5. Occlude external carotid	126/80 to 126/80	0
6. With external occluded, occlude common carotid	126/80 to 54/42	57%
7. Release external carotid	54/42 to 76/60	

The high degree of systolic pressure drop in this instance was similar to the illustrative case just described and to five others in this series, and incontrovertibly proved that trap ligation of this aneurysm could not be performed without grave damage to the ipsilateral hemisphere. The pressure drop was, on the other hand, objective evidence that some form of incomplete occlusion was the procedure of choice. The presence of dysphasia, the right hemiparesis, the progressive deterioration in the state of consciousness and the slow wave focus in the electro-encephalogram suggested the presence of an intracerebral hematoma, a not uncommon complication of acute subarachnoid hemorrhage.[7]

Craniotomy disclosed a mass of loose granular blood clot about and beneath the left internal carotid artery and spreading caudally along the third nerve and medially up the subarachnoid space of the Sylvian fissure. A small ragged edge of blood clot represented the tip of the carotid aneurysm beneath and lateral to the supra-clinoid segment of this vessel. The clot was covered with pledgets of gelatin sponge. The following recordings were taken from the middle cerebral artery, disclosing the marked reduction in intravascular pressure in this vessel after temporary occlusion of the internal or common carotid arteries in the neck and the final pressure range in the middle cerebral artery after progressive but incomplete tantalum band occlusion of the common carotid artery.

		Percentage Systolic Drop
Pressure in middle cerebral artery, left		
1. Occlude common carotid, neck	90/56 to 52/42	42%
2. Occlude internal carotid, neck	90/56 to 36/28	60%
3. Occlude internal carotid, brain	104/82 to 40/32	62%
4. Tantalum band, partial occlusion common carotid artery	62/50	
5. Occlusion common carotid, proximal to band	62/50 to 44/36	29%
6. Occlusion common carotid, distal to band	62/50 to 44/36	29%

At the conclusion of these repetitive tests, which had clearly indicated an inadequate hemispheral cross-circulation and precluded trap ligation, the residual systolic–diastolic pressure in the left middle cerebral artery was lowered to the level of 62/50 by gradual partial occlusion of the common carotid artery. There was an increase in the speech disorder for the first two postoperative days. Thereafter, there was a rapid regresssion in the existing neurologic defects.

CLINICAL RESULTS

The use of this type of objective and repetitive Matas test requires at least a brief consideration of the results obtained in these patients in whom therapy was in some part dictated by intravascular pressure recordings. During the course of a review of the general problem of vascular disease of

the brain, 93 instances of congenital cerebral aneurysms of the brain, proved by operation, arteriography or autopsy or by some combination of these methods of proof, have been studied. Of these, 47 were not treated neurosurgically and 41 succumbed, for a case mortality of 87 per cent. Forty-six cases of proved congenital cerebral aneurysm have been treated by some form of intracranial procedure, with ten postoperative deaths, for an operative mortality of 22 per cent; and with one subsequent death from a recurrent subarachnoid hemorrhage, for a case mortality of 24 per cent.

Of the nine cases of congenital cerebral aneurysm and seven cases of vascular anomaly of the brain studied in the series under discussion, there were four postoperative deaths. In two of these, both with normal Matas tests, intravascular pressure readings demonstrated falls in pressure of 59 and 84 per cent respectively. One of these, Case 2, has been noted in some de-

FIG. 8

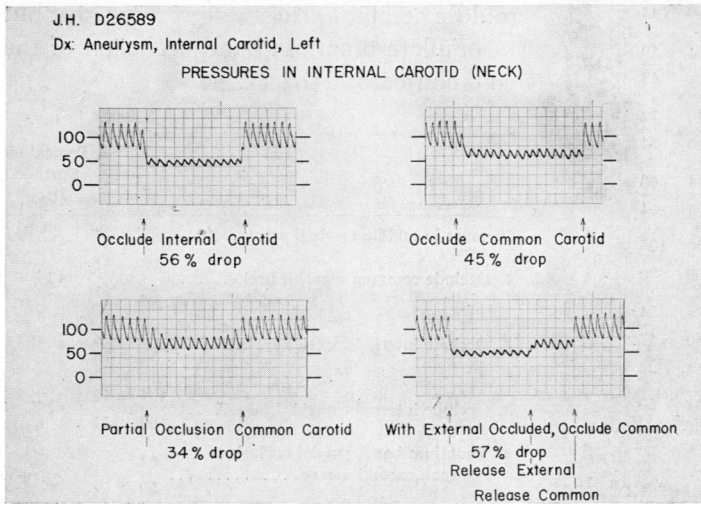

FIG. 8.—Manometric record of marked fall in intravascular pressure in neck vessels following occlusion of indicated vessels (Case 3).

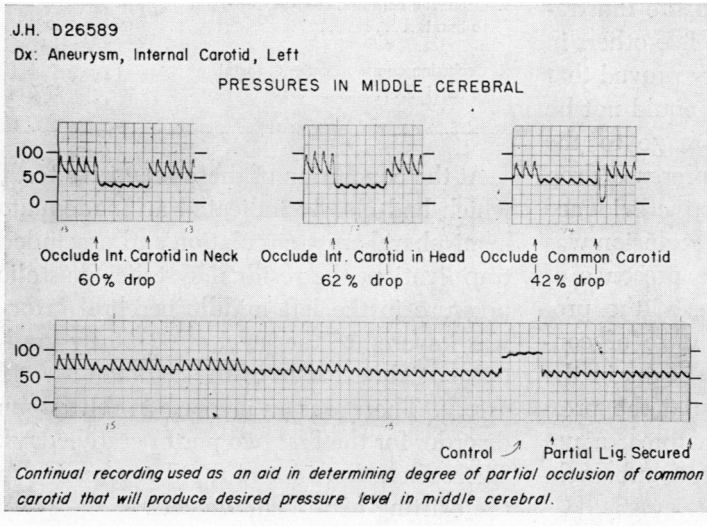

FIG. 9.—Manometric record of intravascular pressure fall in the middle cerebral artery following occlusion of indicated vessels and residual pressure after partial ligation (Case 3).

FIG. 9

tail. A brief description of the three remaining cases follows:

Case 4.—G. J. A congenital cerebral aneurysm of the right internal carotid artery in the region of the posterior communicating artery. An intracranial trap ligation of the artery, and clip ligation of the neck of the aneurysm had been performed when the aneurysm ruptured at the moment of visualization. This forced occlusion of the internal carotid artery intracranially, causing a fall in intravascular pressure in the right middle cerebral artery to 40/34 mm. of Hg. Consciousness was not regained and death occurred 48 hours postoperatively from aspiration of vomitus. Autopsy disclosed absence of the right posterior communicating artery and a relative ischemic change in the distribution of the right middle cerebral artery.

This and subsequent experience suggested that the critical level of intravascular pressure compatible with tissue survival is 50 mm. of Hg.

Case 5.—J. W. A congenital cerebral aneurysm of the anterior communicating artery. Pressure studies are recorded on Tables I and II. A normal convalescence for 23 days followed right craniotomy and intracranial clip ligation. Sudden deterioration followed over a 24-hour period. There was normal lumbar puncture pressure, with death caused by an unrecognized left subdural hematoma.

Case 6.—V. W. An arteriovenous aneurysm of right middle cerebral artery and inferior sagittal sinus. Pressure studies are recorded in Tables I and II. Intracranial ligation of the right internal carotid artery was done. Sudden death occurred from recurrent subarachnoid hemorrhage, proved by lumbar puncture.

SUMMARY

A safe, technically feasible and repeatable technic for the measurement of intravascular pressure in various components of the Circle of Willis has been described. This procedure can be carried out during craniotomy designed to control bleeding from congenital cerebral aneurysms and from vascular anomalies of the brain. Data are presented showing pressure gradients in the middle cerebral artery following temporary and permanent occlusion of proximal vessels, illustrating extreme and normal systolic pressure falls. Three cases are described, demonstrating the value of this objective form of the well-known Matas test in the evaluation of cross–hemispheral circulation.

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DISCUSSION.—DR. DANIEL C. ELKIN, Atlanta, Ga.: The attack upon intracranial aneurysms and arteriovenous communications represents almost a last frontier of neurologic as well as vascular surgery. Although the literature has been extensive, it comprised nothing more than a compilation of