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Carotid Angiography

Crude analysis of 260 consecutive cases with 301 examinations over a period of approximately three and a half years. Bilateral carotid puncture at single sitting classed as one examination; on different days, classed as two examinations. Repeat puncture on different day classed as separate examination.

DIAGNOSES

Diagnoses		Number of Diagnoses
Aneurysm ("congenital") (single and multiple cases)		48
5 with associated intracerebral haemorrhage		
Multiple aneurysms probably due to polyarteritis		1
Arteriovenous malformation		9
4 with associated intracerebral haemorrhage		
Carotid-cavernous fistula		1
Cirsoid aneurysm of scalp (occipital artery		1
Subdural haematoma		10
Interhemispheral haematoma (due to aneurysm of anterior cerebral artery)		1
Extradural haemorrhage		3
Intracerebral haemorrhage		16
due to rupture of aneurysm	5	
due to bleeding angioma	4	
associated with hypertension	1	
" with diabetic arteriopathy	1	
" with massive cerebral softening	1	
" with thrombocytenic purpura	1	
" with depressed skull fracture	1	
" with linear skull fracture	1	
" with penetrating G.S.W. of brain	1	
Cerebral venous thrombosis		2
Arterial thrombosis		16
Internal carotid	6	
middle cerebral artery	5	
middle cerebral artery branches	3	
anterior cerebral artery	2	
Embolism middle cerebral artery		1
Atherosclerosis intracranial vessels		9
Massive intraventricular haematoma from cerebral haemorrhage		1
Massive cerebral softening, without visible thrombosis		2
Cerebral oedema		2
Cerebral atrophy two imitating S.D.H.		4
Hydrocephalus		6
Severe developmental malformation of brain		1
Gliomata		52
Meningiomata		7
Metastases		6
No abnormality detected		60
Unsatisfactory angiogram, no definite abnormality		7
Miscellaneous undiagnosed		2

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Cerebral Angiography

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INTRODUCTION

Cerebral angiography was first introduced as a diagnostic procedure by Moniz in 1927, nine years after Dandy took the first important step in the diagnosis of intracranial lesions by injecting air into the ventricular system. Moniz and Lima at first used 70% strontium bromide in experimental animals, then in human subjects. This was a very toxic medium and was soon abandoned in favour of 25% sodium iodide. Following initial unsuccessful attempts to inject the carotid artery of patients by percutaneous puncture, he proceeded to expose the artery before injection. Sodium iodide was still an unsatisfactory medium, producing a high incidence of reactions, with a mortality rate of 2.6% in 302 angiograms performed by Moniz up to 1931. In 1931, Moniz, for the first time, used 25% thorium dioxide (Thorotrast) for intravascular injection. This medium was widely used for cerebral and peripheral angiography for many years. After establishment of Thorotrast as a contrast medium, the method was more widely used, but the great stimulus towards general acceptance came in 1936, when Loman and Myersson described the method of percutaneous puncture of the carotid artery, avoiding necessity for incision and exposure of the artery. The method was most extensively used in Scandinavia and in 1944, Engeset published work elaborating the percutaneous method and advocating a newer organic iodide contrast medium of Diodrast type. The method was further elaborated by Lindgren in 1947. Since that time, the method has rapidly become established throughout the world and a very large volume of literature has been built up on this subject.

While the term cerebral angiography includes both carotid and vertebral arteriography, percutaneous vertebral arteriography is technically a considerably more difficult procedure than carotid arteriography, with far less practical importance and therefore relatively infrequently performed. This discussion will deal almost exclusively with carotid angiography, but many of the general considerations are applicable to both methods.

Carotid Angiography

For practical purposes, only the percutaneous method is now in use. The procedure can be used in infants and children as well as in adults. Except in children, percutaneous puncture as a rule requires only pre-medication and local anaesthesia, though occasionally patients unable to co-operate require general anaesthesia.

In all cases, even with the use of general anaesthesia, infiltration of the carotid sheath with 1% Novocaine is highly desirable. If this is omitted, severe vasospasm may be provoked, rendering puncture of the artery more difficult and frequently interfering with circulation of the contrast medium following injection.

The actual technique of puncture is not difficult, nor can it be said to be easy. Ease of puncture varies considerably from patient to patient, and is essentially a matter of continued practice. With experience, failure to puncture is a rare event. Occasionally an unco-operative patient will so hinder the procedure that puncture can only be performed satisfactorily under general anaesthesia.

An 18 needle of lumbar puncture type, with a short but sharp bevel is directed into the common carotid artery well below the level of its bifurcation. (Some workers prefer selective puncture and injection of the internal carotid artery, with separate injection of the external carotid artery if later found to be necessary, i.e. where there is suspicion of abnormality involving the external carotid circulation also, e.g. a meningioma may derive part of its blood supply from the internal and part from the external carotid circulation, with one or other of these usually predominating.)

Injection of the common carotid artery allows satisfactory contrast filling of both the internal and external carotid circulations as a rule. The contrast medium usually circulates so much more slowly through the external than the internal carotid system that superimposition of the arteries of the two systems is rarely a problem.

The amount of contrast medium injected varies, but as a rule is between 6 and 10 c.c. The injection is made as rapidly as possible for best contrast density. In effect a "bolus" of radiopaque medium is sent circulating through the vessels and rapid serial radiographs are obtained, to demonstrate this bolus circulating through the major arteries, minor arteries, capillaries, minor veins, major veins and dural sinuses. The duration of the above cycle from the stage of filling of the major arteries to complete clearance of the contrast medium from the skull is variable from case to case and from time to time in a given case, but averages approximately six seconds. Any number of serial films can be taken during the period of circulation, depending on the serial apparatus available, e.g. up to ten radiographs per second with the most modern serial changes. Cine-radiography may be used to follow the entire cycle.

In practice, 3 to 4 films for each sequence is satisfactory, since the above phases are usually superimposed to some extent on each radiograph. It is usual to perform a minimum of two injections, one for a lateral series of projections and one for an A. P. series. Stereoscopic projections can be obtained, but these can never replace the accuracy of localisation possible with views in two planes at right angles to one another. Occasionally, additional projections may be desirable, requiring further injections under varying conditions. Rarely, up to six injections may be necessary. Every effort should be made to keep the total amount of contrast medium injected to a minimum, since no completely harmless contrast medium has yet been found. To this end, the so-called two-plane serial radiography has been developed, using two X-ray tubes and two sets of films set in different planes and exposed simultaneously during a single injection. This method, however, results in considerable radiation scatter problems, making protection of personnel very difficult.

Preparation of the Patient

The type of preparation required depends on the state of the patient. If the patient is deeply comatose, no pre-medication is necessary or advisable. Usually moderate pre-medication is given, e.g. nembutal, pantopon and scopolamine, demerol, etc., alone or in combination. Papaverine may be desirable to diminish tendency towards vasospasm where organic iodides are to be injected. The general preparation of the patient will be that required for a general anaesthetic.

Contrast Media

Unfortunately, no wholly satisfactory contrast medium has yet been developed. The media by far the most commonly used are the organic iodide compounds of Diodrast or similar type and Thorotrast.

(A) *Organic Iiodide Compounds*

The more recently developed of these compounds are of very low general toxicity, but owing to their hypertonicity in the concentrations required, are prone to cause vasospasm and to disturb somewhat the blood-brain barrier. These effects are roughly proportional to the amount and concentration of the medium injected and are a potential hazard. The lowest quantity and concentration compatible with satisfactory filling and contrast density of the cerebral vascular system is employed. Of these compounds, Diodrast (Diodone) is most frequently used. Of this material, not more than 15 c.c. should be used per injection and the concentration should not exceed 42%, except under certain circumstances, e.g. where a very large vascular malformation is present, with an enormous arterio-venous shunt, by-passing the brain substance.

In general, 8 c.c. of 35 to 40.5% Diodrast is found to be entirely satisfactory for each injection. Both right and left carotid arteries may be injected at a single sitting, but it is unwise to use a total of more than 60 c.c. of contrast medium. Sensitivity reactions to these media are not very common and only very rarely serious. A further disadvantage of these media is a fleeting sensation of heat in the head and face on the injected side. Individual sensitivity to this effect evidently varies considerably. With adequate warning, most patients are not greatly disturbed by this, but occasionally the sensation is sufficiently unpleasant to cause the patient to move violently, immediately after the injection, sometimes causing unsatisfactory films, due to blurring by movement. This effect is a property of the hypertonicity of the medium and not of any irritant effect of the iodide.

(B) *Radioactive Iodine Compounds*

The alternative medium is Thorotrast, which, although non-toxic in the chemical sense, is radioactive. While the radioactivity is very low, the half-life of the medium is very prolonged. The colloidal particles in the suspension are taken up and stored permanently in the reticulo-endothelial system. While the immediate reactions of the organic iodides are avoided, a number of recent reports indicate the very real risk of eventual sarcomatous changes in the reticulo-endothelial system or at the site of inadvertent extravasation of the medium. Cirrhosis of the liver and fibrosis of the spleen have also been reported and in some patients, large and numerous masses of calcium may be shown throughout the liver and spleen, years after the injection of Thorotrast. In general, the use of Thorotrast is now limited to the elderly group of patients (over 55 to 65 years), since in these, the results of vasospasm are more hazardous, with a greater tendency towards precipitation of thrombosis or cortical ischaemia without thrombosis. In this elderly group, the remote risks of Thorotrast (8 to 15 years following injection) are least likely to be of practical importance. As in the case of organic iodides, the quantity of Thorotrast injected should be kept to a bare minimum.

Complications

A wide divergence in incidence of complications in different centres is apparent. This is most probably due to a variation in the techniques used. In our series of 301 consecutive examinations over a period of approximately three and a half years, no deaths directly attributable to cerebral angiography have occurred. One case of hemiplegia occurring shortly after angiography was seen, in a case found to have a large, very vascular glioblastoma in the Rolandic area. In a very few cases, transient increase in the extent or severity of pareses and paralyses have occurred at varying intervals following injection, which could be attributable in part to angiography.

Sensitivity reactions to the organic iodides are seen from time to time. As a rule these are minor, consisting of transient nausea, flushing, urticarial lesions and occasionally with vomiting. Severe sensitivity reactions are very rare with present media, but on rare occasions anaphylactic reactions occur and, very rarely, these may be so severe as to be the direct cause of death.

Local complications of the procedure are rarely of any real importance. They include cervical haematoma, temporary paralysis of the vagus and cervical sympathetic nerves, swelling and bruising of the mucous membrane of the pharynx, which may cause discomfort on swallowing for a short time.

Under certain circumstances, local complications in the carotid artery may arise, though fortunately these are rare. Subintimal injection may cause stripping of the intima, occasionally causing a risk of thrombosis.

The intracranial compications may occur immediately or within twenty-four hours. Over this period it becomes dubious whether the changes can be attributed to angiography. Various transient or permanent pareses and paralyses, up to hemiplegia may occur. Fortunately these are not common. These complications are most frequent in cases of large and vascular tumours and where severe cerebral atherosclerosis is present. Under the latter circumstances, vasospasm may be sufficient to cause cerebral thrombosis, or cerebral ischaemia without actual thrombosis.

Histological study of the brain following injection of iodides has shown that there is a possibility of damage to the cerebral capillaries, with increased permeability. The degree of this damage is proportional to the concentration of the medium and the length of time during which the medium is applied to the vessel wall. Experimental evidence also indicates that a summation of noxious effects occurs if injections are given at less than ten to fifteen minute intervals. A brain, the seat of pre-existing disease, is probably more sensitive to the effects of the injection.

Occasionally rupture of an aneurysm is seen at the time of injection, either before, during, or after, the injection. This is most probably caused by hypertension due to initial apprehension or to reflex hypertension caused by the injection. It must be remembered that many patients subjected to carotid angiography are gravely ill and in a very precarious state with markedly altered intracranial pressure equilibrium. Even minor changes in this equilibrium may seriously effect the state of the patient, whether the changes are caused by pneumography or cerebral angiography. On the whole, cerebral angiography is a lesser risk and causes less disturbance to the patient than encephalography. Head shaving and burr-hole formation for ventriculography is avoided. Serious complications of angiography, such as a permanent hemiparesis or hemiplegia occur rarely and usually occur in those patients in whom the prognosis is worst, e.g. with very large malignant vascular gliomata. The very occasional death is most likely to occur in this group of patients.

In spite of the above risks, which must always receive due consideration, the importance of early and accurate diagnosis in these seriously ill patients must be kept in mind. There is no doubt that cerebral angiography has taken its place as a very safe procedure, which is relatively simple and not time consuming under the proper conditions. It can be used as an outpatient procedure.

Indications for Carotid Angiography

Angiography is the method of choice where lesions of the vascular system or vascular tumours are suspected. In such cases, cerebral angiography can give a precise pathological diagnosis.

A. *Investigation of Subarachnoid Haemorrhage*

1. Intracranial aneurysms.
2. Arteriovenous malformations.
3. Cerebral Tumours and miscellaneous lesions.

B. *Arterial Occlusion*

1. Thrombosis.
2. Embolism.

C. *Cranio-cerebral Injury*

1. Extradural haematoma.
2. Subdural haematoma, acute and chronic.
3. Intracerebral haematoma.
4. Cerebral oedema.
5. Carotido-cavernous fistula.

D. *Intracranial Expanding Lesions* (Non-traumatic)

1. Certain aneurysms (non-bleeding).
2. Arteriovenous malformations (non-bleeding).
3. Meningiomata.*
4. Malignant gliomata.*
5. Metastases.*
   *pathological diagnosis very frequently possible in addition to demonstration of exact size, shape and position of the lesion.
6. Avascular Expanding lesions. position and size more or less accurately shown, depending on site, by virtue of displacements and deformities of cerebral arteries and veins or both.
   (a) one of the above, 3, 4, 5, which fails to show characteristic pattern.
   (b) "benign" gliomata.
   (c) abscess.
   (d) granuloma.
   (e) miscellaneous.

The following general rules govern the choice of the primary diagnostic procedure (cerebral angiography, encephalography and ventriculography). It goes without saying, that full routine radiography of the skull should always precede any diagnostic procedure requiring operative interference.

If a supra-tentorial vascular lesion is suspected, angiography should be used initially and will very frequently be the only special radiological investigation required. If the position and size of an avascular or poorly vascularised lesion is not adequately shown with angiography, encephalography or ventriculography may be required as a secondary procedure, to complete the investigation.

Expanding lesions of the posterior fossa and of mid-brain are so accurately localised by pneumography that this will be the method of choice where such lesions are suspected. Cerebral atrophic lesions, suspected avascular deep-seated supra-tentorial expanding lesions, etc., are usually best demonstrated by pneumography. In some instances, cerebral angiography may be required following pneumography, further to elucidate.

Thus it is apparent that, while there are definite indications for angiography or pneumography as the diagnostic method of choice, in many instances the two methods should be used in a complementary fashion.

Anatomical Considerations

Common carotid injection will as a rule show the following blood vessels. In addition, certain aspects of function will be shown, such as the amount of circulation through the different branches. Anatomical variations are numerous and considerable experience is required in differentiating anatomical variations from pathological changes. This is a relative disadvantage of angiography, compared with pneumography. Anatomical variations of the ventricular system are less common and of smaller range. Common carotid injection will as a rule show the following blood vessels.

1. *Arterial*

Distal common carotid artery and its bifurcation.

External carotid artery (with its cervical, facial and scalp branches.

Middle meningeal artery.

Cervical portion of internal carotid artery.

Internal carotid artery in carotid canal.

Infra-sellar portion of Internal Carotid Artery.

Carotid siphon (parasellar and suprasellar portion of internal carotid artery).

Major branches of internal carotid artery (in order of origin).

Ophthalmic artery.

Posterior cerebral artery (only filled in 25 - 30% of cases).

Anterior choroidal artery.

Bifurcation of Internal Carotid Artery.

Anterior cerebral artery.

Anterior communicating artery

Fronto-polar artery.

Pericallosal artery.

Calloso-marginal artery.

Middle cerebral artery.

Ascending fronto-parietal artery.

Sylvian group of vessels.

i. parietal branch.
ii. angular branch.
iii. posterior temporal branch.

2. *Venous*

Cerebral cortical veins.
Superior and inferior sagittal sinus.
Straight and lateral sinuses.
Basal vein (Rosenthal).
Internal cerebral vein and its major tributaries.
Vein of Galen.
Anastomotic veins of Trolard and L'Abbe.

It must be remembered that only the supra-tentorial area is covered by carotid angiography and the area of distribution of the posterior cerebral artery is only demonstrated in 25 to 30% of cases. Fortunately, the latter area is relatively infrequently involved in vascular lesions.

In spite of the wide range of anatomical variations in the cerebral vasculature, certain fixed anatomical points are demonstrated by the angiogram. Among these are:

1. The anterior cerebral arteries and pericallosal arteries course posteriorly side by side in the longitudinal (sagittal) fissure. In the fissure, these arteries are, for practical purposes, in the midline, marking the latter.
2. Genu of corpus callosum (the anterior cerebral artery forms a smooth curve convex anteriorly over the genu).
3. The middle cerebral artery and the proximal portions of its branches mark the Sylvian fissure.
4. The curve of the strio-thalamic vein at the junction with the internal cerebral vein, marks the posterior wall of the foramen of Munro.
5. The posterior extremity of the tentorial opening is marked by the confluence of the inferior sagittal sinus, straight sinus and vein of Galen.

Angiographic Findings

Very numerous papers have accumulated, describing in great detail the findings in a wide variety of lesions producing angiographic changes. Without the aid of illustrations or reproductions of radiographs, any detailed discussion of findings must obviously be tedious and unsatisfactory. Description of certain cardinal changes may, however, be worthwhile.

Subarachnoid Haemorrhage

The optimum time for angiography following subarachnoid haemorrhage is disputed. Some believe that angiography should be performed as soon as possible after subarachnoid haemorrhage, so that if emergency craniotomy is required, the diagnosis is known. Others state that since the protective spasm of in the intracranial arteries is most severe in the days immediately following the haemorrhage, cerebral angiography performed immediately after the haemorrhage is more likely to produce transient or permanent neurological complications. This school recommends injection some seven to ten days after the last subarachnoid haemorrhage, stating that this avoids the possibility of a combination of protective spasm and spasm caused by hypertonic media, yet this interval falls short of that period (2 - 4 weeks) in which there is maximum risk of recurrence of the haemorrhage.

1. *Intracranial Aneurysms*

The large majority of cases of cerebral haemorrhage (approximate 80-85%) are found to be due to rupture of an aneurysm. It is stated that in these cases local dissecting intramural haemorrhage occurs, giving rise to a slow seepage. Gross frank rupture is said to be rare. The vast majority of these aneurysms are due to superimposition of degenerative changes upon a developmental defect of the media. These aneurysms usually occur at points of bifurcation of the cerebral arteries and some 75% arise on the anterior half of the circle of Willis. The junction of the anterior cerebral artery and anterior communicating artery is the site of special predilection. Almost all of these aneurysms are between 0.2 to 1.5 cms. in diameter. On the angiogram, these aneurysms appear as small "berries" attached to the arterial tree. It is said that one-third of cases of aneurysm are associated with developmental anomalies of the circle of Willis, demonstration of which can be very important in influencing surgical treatment. An additional injection, during compression of the contralateral carotid artery, may be necessary, in order to demonstrate the collateral circulation possible from one side to the other, via the anterior communicating artery. Arterial spasm is frequently seen in recent subarachnoid haemorrhage and if severe, this may lead to arterial thrombosis or to cortical necrosis without actual thrombosis, at a distance from the aneurysm or other primary lesion.

Occasionally, larger aneurysms are seen, up to 5 cms. or more in diameter. These larger aneurysms frequently contain thrombus, show curvi-linear calcification on routine films and present primarily as an expanding space occupying lesion. These very large aneurysms rarely cause haemorrhage.

Aneurysms may show greater or lesser neck formation, affecting the ease of application of a clip at operation. Aneurysms are multiple in over 10% of cases and injection of both common carotid arteries is necessary for full assessment. Aneurysms in certain sites (particularly in the Sylvian fissure) are prone to burrow into the brain as they enlarge. Rupture of such an aneurysm will frequently cause an intracerebral haematoma, particularly in the temporal lobe, in addition to subarachnoid haemorrhage. Evacuation of such haematomata is discussed later. Arterial thrombosis may be found in association with cerebral aneurysm.

Other forms of aneurysm, e.g. mycotic aneurysms or aneurysms secondary to polyarteritis occur but are rarely encountered.

Post-operative angiography is frequently required, to demonstrate the effectiveness (or otherwise) of attempted occlusion of the aneurysms by application of a silver clip, packing, etc., and of the removal of intra-cerebral haematomata.

2. *Arteriovenous Malformations*

(Angiomata, arterviovenous fistulae)

This type of lesion may present as an expanding intracranial lesion, as a cause of cerebral atrophy owing to shunting of blood away from the brain, or as a bleeding lesion (subarachnoid or intra-cerebral haemorrhage).

These lesions vary from the most minute lesions (which may be so completely destroyed at the time of their haemorrhage, that they can no longer be identified at angiography or even at autopsy), to very large lesions in which massive arteriovenous shunts are present, causing ischaemia of a large area of brain. Thus considerable underlying cerebral atrophy may exist. Approximately one-third of these lesions will show signs on plain films, e.g. increased size of the foramen spinosum on the affected side, increased vascular grooves and sinuses of the skull vault and lastly calcification within the malformation in some 5%.

Small angiomata are usually fed by only one branch of the internal carotid artery. The largest forms are frequently fed by two or all three major branches of the internal carotid artery. Sometimes an intracranial angioma is fed in part by a branch of the external cerebral artery. This may be apparent on clinical examination, owing to a superficial bruit and enlargement, with tortuosity, of one or other of the arteries of the scalp. Some angiomata are partially intracranial and partially extracranial.

The following are the major features of arteriovenous malformations:

i. The hypertrophied carotid vessels.

ii. The hypertrophied vessel or vessels supplying the angioma. One or more feeding arteries may be seen, showing greatly increased calibre and considerably exaggerated tortuosity, resulting from the greatly increased blood flow shunted through the malformation.

iii. The relatively poor filling of vessels not supplying the angioma, again an expression of a large shunt, deviating blood from the normal vessels and from the brain.

iv. The huge efferent veins draining the malformation and leading to the venous sinuses. Owing to the rapid circulation through the malformation, the arteries feeding the malformation, the malformation itself and the draining veins and sinuses are usually all shown filled together on the first film of angiogram.

v. The capillaries of the brain are bypassed.

vi. The lack of filling of the vessels in the phlebograms. The rapid shunt clears the contrast from the brain in a fraction of the time normally required for the circulation.

Many angiomata fill from both right and left carotid arteries, but usually one side predominates in supplying blood to the malformation. Some of these angiomata, particularly the more superficially lying, can be dissected out in toto. In others, one or more of the feeding arteries can be occluded by application of a clip, cutting off or reducing the blood flow through the malformation. Even if the blood flow is only reduced, this may be sufficient to cause thrombosis in the angioma, as in aneurysms similarly treated, preventing further enlargement and risk of haemorrhage. Demonstration of the exact anatomy and identification of the feeding vessels is of primary importance prior to surgical attack, which is the only possible satisfactory treatment.

Owing to the large volume of blood contained in the larger angiomata, greater quantities and greater concentrations of contrast medium may have to be injected to demonstrate the lesion adequately. This is relatively safe in such conditions, as the contrast medium is largely shunted past the brain. Demonstration of associated intra-cerebral haematoma is also of importance before surgery is undertaken.

Post-operative angiograms are desirable, to show the effectiveness or otherwise of the form of surgical treatment enjoyed.

3. *Arterial Occlusion*

The relative frequency of thrombosis of the internal carotid artery has only been realised since the advent of cerebral angiography as a common diagnostic procedure. While atherosclerosis is relatively common at an early age in this artery, calcified plaques are hardly ever seen on radiography of the neck, whereas calcification is commonly seen in the carotid siphon, as in other major arteries of the body. The commonest site of occlusion of the internal carotid artery is at a point 1 to 2 cms. beyond the common carotid bifurcation, the next most frequent site being in the distal siphon. Characteristically, contrast is seen only in the external carotid circulation, with none visible in the internal carotid circulation (though occasionally a free collateral circulation is developed via the branches of the external carotid artery and the ophthalmic branch of the internal carotid artery, allowing some flow of contrast into the siphon and major branches of the internal carotid artery). This may be due to incorrect position of the needle tip, but the latter is unusual with good technique. A lateral view of the neck is obtained during a second injection and this will demonstrate the thrombosis, showing a conical tapering of the proximal internal carotid artery to the point of complete obliteration.

Occlusion of the major branches of the internal carotid artery will be demonstrable, but occlusion of the very small arterial branches cannot be recognised as a rule, owing to the wide range of normal variation in the vascular anatomy.

The occlusion of an artery by an embolus cannot be distinguished from that due to thrombosis on angiography alone.

4. *Subdural Haematoma*

Cerebral angiography has a very definite place in the diagnosis of subdural haematoma, in spite of the ease with which burr holes may be placed in the skull. The exact site and size of the subdural haematoma can usually be demonstrated with great clarity. Its unilateral or bilateral nature can be shown. Occasionally, a haematoma may be demonstrated in the longitudinal fissure, between the cerebral hemispheres. The latter would be difficult to approach via a burr hole placed in the usual site. Occasionally also, a case suspected as being one of glioma is shown to be due to chronic subdural haematoma and vice-versa.

In the arterial phase, displacement of the major arterial branches characteristic of a space occupying lesion at the affected site will be seen. In the capillary phase, when the brain is diffusely opacified by the contrast medium contained in the capillaries, the brain surface can be identified and can be seen to be displaced inwards away from the inner table, leaving an avascular space (occupied by the haematoma) of variable size and position.

An extradural haematoma will usually show an identical appearance on angiography.

5. *Intracerebral Haematoma*

Angiographic appearance is that of an avascular space occupying lesion, indistinguishable from other avascular space occupying lesions such as a cerebral abscess or avascular glioma. The circumstances of the case will usually allow differentiation, particularly if the primary cause of the haematoma is demonstrated on the angiogram.

6. *Cerebral Oedema*

A displacement of the midline vessels to the opposite side will be apparent, with some stretching (straightening of the normal undulant curves) and slight separation of the arterial branches, without definite individual displacement or deformity of the latter.

7. *Carotid-cavernous Fistula*

In the first arterial phase, contrast medium will be shown filling the internal carotid artery and in addition, the cavernous sinus on the ipsilateral side or possibly on both sides. The sinus will be enlarged and a reversed blood flow will be shown in its venous tributaries. These tributaries fill in a retrograde direction and are shown to be dilated and more tortuous than normal. The ophthalmic veins are shown to be markedly dilated and tortuous, with filling of the veins of the face and neck, simultaneously with the filling of the carotid artery.

8. *Hydrocephalus*

Minor degrees of hydrocephalus will not be appreciated on angiography. More advanced hydrocephalus causes an increase in the radius of the curve of the anterior cerebral artery over the genu of the corpus callosum, due to dilatation of the frontal horns of the lateral ventricles. There will be some elevation and stretching of the peri-callosal artery also, with a generalised separation (splaying) of the branches of the anterior and middle cerebral arteries.

9. *Intracranial Expanding Lesions*
   A. *Avascular*

As a general rule, blood vessels at a distance from the mass are simply displaced bodily away from the mass, while those adjacent to the mass tend to show severe localized distortion in addition to greater or lesser displacement. Normally, the cerebral arteries show smoothly curving and undulant courses. Mass lesions cause stretching of vessels over the contour of the mass or over the involved lobe. Where blood vessels are surrounded by a tumour, which has infiltrated around the vessels, regular or irregular narrowing of this part of the vessel may be seen, often with a change in the rate of blood flow through the vessel and with kinking or irregular angular deformities.

As a rule, discrete masses produce the most characteristic changes in the vasculature. Infiltrating lesions or those showing some degree of infiltration are more difficult to localize precisely and estimation of the size of the lesion is much more difficult.

Superficial and not very deep masses in the cerebral hemispheres will, as a rule, cause marked deformity of the arteries, while deep cerebral lesions, e.g. tumours of the basal nuclei, will cause greater deformity of the deep cerebral veins than of the cerebral arteries.

Tumour Localization
(Avascular Tumours)

For the purposes of classification of the angiographic changes, the following topographical divisions are used (modified from Wickbom, 1948).

Accuracy of localization is indicated thus:

**** Very good
*** Good
** Fair
* Poor

i. *Frontal*

a. Frontal pole (****)
Posterior and contralateral displacement of anterior cerebral artery, flattening of curve over genu. Frontopolar artery also displaced to opposite side with anterior cerebral artery (negative fronto polar sign).

b. Subfrontal uni/bilateral (****)
Posterior displacement, elevation with upward and backward bowing of anterior cerebral artery, sharpened curve over genu. Contralateral displacement if unilateral. More or less symmetrical displacement of both anterior cerebral arteries if bilateral subfrontal lesion is present.

c. Frontal parasagittal (***)
Depression of pericallosal and callosa-marginal arteries, with contralateral displacement of these. The curve of the anterior cerebral artery over the genu of corpus callosum may again be sharpened, this time by depression of the upper limb, rather than elevation of the lower limb of the curve as in (b).

d. Low Lateral frontal (***)
Depression of middle cerebral artery and proximal portions of the Sylvian group of vessels. Contralateral displacement of anterior cerebral artery.

e. Frontal convexity (**)
Changes are a combination of (c) and (d), but in each case the vascular displacement and deformity is less severe. (c) or (d) type vascular displacement may predominate.

f. Deep frontal (infiltrating or involving corpus callosum) (**)
Variable deformity of anterior cerebral artery (anterior displacement or irregularity of genu curve) elevation of pericallosal artery. Usually severe deformity of the anterior portion of the internal cerebral vein and its tributaries.

ii. *Parietal*

a. Parasagittal (****)
Depression of pericallosal and anterior cerebral arteries, but more posteriorly than (c), with contralateral displacement of anterior cerebral artery and its branches.

b. Convexity and Deep (***)
Contralateral displacement of pericallosal and calloso-marginal arteries greater than that of anterior cerebral artery. Depression and lateral displacement of distal portions of the three main branches of middle cerebral artery (Sylvian group) or in some cases separation of these arteries by upward and downward displacement (splaying over the tumour).

iii. *Temporal*

a. Anterior
Upward displacement and upward stretching and bowing of middle cerebral artery and proximal portions of branches in the Sylvian fissure, with elevation of the supra-clinoid portion of the carotid siphon.

b. Posterior
Elevation of middle or posterior portions of the Sylvian vessels, with stretching and upward bowing. Little or no displacement of carotid siphon and proximal middle cerebral artery.

c. In Sylvian fissure
Essentially as in (b), but with separ-

ation of the individual branches of the middle cerebral artery one from another. Marked medial and some inferior displacement of the posterior cerebral artery (where seen filled).

In all of the above, greater or lesser contralateral displacement of the anterior cerebral artery is seen, but fronto-polar branch is usually less displaced than anterior cerebral artery (positive fronto-polar sign).

iv. *Occipital*

Anterior displacement of the posterior portion of the Sylvian group of arteries, causing "buckling" of the branches (concertina fashion). More accurate localization possible where posterior cerebral artery has filled.

v. *Suprasellar* (e.g. craniopharyngioma, suprasellar extension of pituitary tumours, etc.)

Lateral displacement of supra-clinoid portion of siphon and bifurcation of internal carotid artery. Elevation of anterior portion of internal cerebral vein, with sharpening of its anterior curve (encephalography, with filling of the frontal horns, third ventricle and basal cisterns gives far better demonstration of this type of tumour.

The assessment of accuracy of localization in the above topographical divisions is somewhat arbitrary, the percentage accuracy depending to a considerable extent upon the number of infiltrating as opposed to circumscribed, and vascular as opposed to avascular tumour included in each group. The circumscribed and vascular tumours will be better localized on the whole.

B. *Localization of Vascular Tumours*

Where the tumour is vascular, accuracy of localization rises sharply. In the most vascular tumours, the exact size and position of the tumour is shown.

In this group, exact pathological diagnosis is frequently possible, as many of these tumours show characteristic pathological vascular patterns.

a. *Gliomata*

i. Glioblastoma

The large majority are vascular and may show the following vascular patterns alone or in combination.

1. long and short irregularly coursing tumour blood vessels.
2. multiple small arterio-venous fistulae.
3. small irregular tumour sinuses.
4. circularly coursing vessels around the periphery of the tumour.

Many of these pathological vessels may closely resemble smaller forms of normal vessels, but tend to show an irregularly varying lumen, as opposed to the normal regular gradually decreasing lumen.

b. *"Benign" Gliomata*

These show pathological blood vessels less frequently than glioblastoma.

ii. Meningiomata

Approximately 6C% show visible tumour blood vessels.

1. diffuse homogenous contrast staining (capillary blush).
2. Numerous small blood vessels similar to those seen in glioblastoma, but with more regular arrangement, e.g. radial.
3. demonstration of partial blood supply from a branch of the external carotid circulation in some cases.

iii. Metastases

These are frequently multiple. Approximately 50% are vascular. Some show appearances similar to glioblastoma and some similar to the capillary blush of meningioma.

The following trend in the use of methods of investigation is of interest:

Cerebral angiography is steadily becoming more widely used in cases previously submitted to pneumography, just as, in many important centres, encephalography is being more and more frequently used in place of ventriculography.

Vertebral Angiography

A number of different techniques have been developed, including catheterization of the vertebral artery and retrograde injection via the subclavian artery. The number of methods is an indication of the lack of a wholly satisfactory technique. The most satisfactory is probably the anterior percutaneous approach, low in the neck. The technique is relatively difficult. Since it is impossible to avoid striking sensory nerves in seeking the artery, a general anaesthetic is required.

The purely vascular lesions and vascular tumours of the posterior fossa will be demonstrated as a rule sufficiently well to allow a pathological diagnosis, as opposed to the purely dimensional and positional diagnosis offered by pneumography. The surgical attack of these lesions, however, is more frequently impractical than in the supra-tentorial counterparts. There is therefore at present less call for the method. This position may well change with progressing surgical and anaesthetic (e.g. hypothermia) techniques.

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Final diagnosis of fracture depends upon X-ray examination which should include full length of bone, the joint above and below, and sufficient views to show fracture and any displacement.

In congenital hip, the head of the humerus rides high, wide, small and late.

Hazards and Precautions In Diagnostic Roentgenology

Fennell Archdekin, Meds '57

A recent survey of vocational ailments suffered by physicians listed X-ray injuries third. The pioneers of roentgenology who fell victims of radiation injuries are justly honoured as martyrs whose sacrifices paved the way for safety in the utilization of this valuable diagnostic and therapeutic tool. However, injuries caused by X-ray overdosage today must surely arise from ignorance, carelessless, or haste, because now the means of protection are known, standardized, and easily available. In addition, the greatest majority of X-ray installations are as safe as designing can make them.

The deleterious effects of ionizing radiation have been popularized since Hiroshima and Nagasaki, but the "atomic era" might better date back to the time of the discovery of X-rays before the turn of the century. Since the first radiation burn described in 1896 by Elihu Thomson, many more manifestations of radiation overdosage have been recognized. The various tissues of the body that are affected in order of decreasing sensitivity are: the blood forming tissues, the most susceptible being the lymphoid tissue; basal epithelium of secretory glands, gonads, skin, mucous membranes, gastrointestinal tract, lung alveoli and liver ducts, as well as tubular epithelium of the kidneys; endothelium of the blood vessels, pleura and peritoneum; connective tissue cells; muscle cells; bone cells; and nerve cells. The literature dating back to the first century contains numerous accounts of lesions due to X-radiation occurring in the above tissues, so that now it can be said that "any amount of radiation to either patient or personnel which is not necessary, is too much".

There are three possible sources of X-ray exposure of patients or operating personnel: the useful beam, direct radiation (radiation from target other than the useful beam), and scattered radiation from objects in the useful beam. The patient is exposed to all three, but this exposure varies and is controlled by the radiological procedure so that the permissible exposure is not exceeded. However, the factors limiting the exposure of the personnel are found in the protective design of the X-ray equipment, protective materials external to the apparatus, and the techniques and procedures employed.

Prior to any X-ray diagnostic procedures, inquiry should always be made as to the occupation of the patient and the amount of radiation of any kind that has been received in the past, that is, diagnostic, therapeutic, or occupational. If there is a history of recent exposure, further inquiry is indicated. In this respect, it is recommended that all radiologists and dentists should keep records of doses given, the field sizes, and radiation qualities used in all diagnostic procedures. It is hoped that in the near future, every individual will have a "Radiation Certificate" on which will be recorded details of all radiation exposure (medical and occupational) received throughout life.

Further precautions should be observed in the diagnostic investigation of patients either radiographic or fluoroscopic. The smallest possible cross-section of the useful beam should be used. As a general safeguard, filters (.5 mm - 3 mm Al.) should be used to filter out the softer rays that are useless diagnostically, but are injurious to the superficial tissues. The tube for fluoroscopy should not be nearer than 30 cm to the skin. Gonads should be protected in all irradiations by collimation of the beam or by protective screens. An automatic timer should indicate the length of the radiologic procedure. A few of the potentially more prolonged exposures are catheterization of the heart, tomography, transverse studies of the lumbar vertebrae, pelvimetry, angiography, the setting of fracrures, and the removal of foreign bodies. Since little is known about the action of radiation on growing tissues, caution should be used in repeating diagnostic examinations on children.

Roentgenology as a specialty neglected the factor of safety for the first quarter of the century. The British Roentgen Society, after the First World War, put forward protective measures, but they were not put into use in Britain until after they were approved by the International Commission on Radiological Protection in 1928. This organization was set up to make recommendations on radiation safety standards.

In the Recommendation of the International Commission on Radiological Protection (Revised December 1, 1954), the maximum permissible doses for whole body irradiation, that is, skin, blood-forming organs (in a significant volume), gomads, and eye, is 300 milliroentgens per week. The maximum permissible doses for partial body irradiation, that is, hands and forearms, feet and ankles, head and neck, is 1,500 mr per week, provided that in case of irradiation of the head, the dose in the lens of the eye shall not exceed 300 mr per week.

There are several methods of measuring the amount of exposure to radiation. The most popular are the small pocket ionizing chamber and the monitor badge (a small dental film). The latter are provided by the Monitoring Service of the Department of National Health and Welfare. Two films are sent, one is a control—a measure of background radiation; the other is worn for two weeks. Then, they are sent to Ottawa where scientific exposure tests are made. This method has been found very effective. The badge is a constant reminder of danger to the individual as well as providing a method of quantitatively measuring the radiation. The Victorian Ionization Chamber Integrating Dosimeter is a more elaborate apparatus and is used to check the safety of X-ray equipment, re-shielding, etc. Personnel monitoring should be supplemented with periodic medical examinations, which should include a general physical examination with special reference to evidence of atrophic skin changes or of dermatitis. Also, periodic haematologic studies should be carried out to detect leukopenia, thrombocytopenia, or anaemia, in other words, the first evidences of over-exposure.

The exposure of operating personnel, as stated before, depends first on the design of the X-ray equipment. The protective tube housing should satisfy requirements for the diagnostic-type tube housing, that is, allowing a leakage of 100 mr. per hour maximum one metre from a continuous X-ray source with closed window and at its maximum rated current for the maximum rated voltage. Apertures or cones that limit the useful beam should provide the same degree of protection. Further specification in fluoroscopic equipment is necessary. The area of the fluorescent screen should provide an adequate margin around the X-ray beam (that is, 5 cm), when the screen is at its greatest distance from the tube and for any angulation of the table. This can be accomplished by an adequate diaphragm in the tube protective enclosure and by correct mounting of the screen. A protective glass sheet of lead of adequate thickness should cover the fluorescent screen taking into consideration the protection afforded by the patient. A switch operated by hand, knee, or foot for the tube should be accessible to the examination position in order to utilize the X-ray to the maximum with the least amount of exposure. An automatic switch for radiography is desired as it is not necessary for the radiologist or technician to be near the patient at the time of the exposure.

The second factor limiting the exposure of the personnel are protective measures outside the X-ray apparatus. Protective clothing should be worn, such as gloves, aprons, coats and shinbone protectors, in order that the permissible doses are not exceeded, especially during flouroscopy, as the scattered radiation from the patient is of the "hard type". Too often surgeons take off the awkward, hot gloves to set a fracture. The result of their haste may be a dermatitis or even carcinoma, whereas even gloved hands should not be placed in the direct beam. Also, old cracked gloves should be discarded, replaced preferably by gloves with washable linings. Personnel in a radiological department should not hold a child or a mental patient during radiography. Parents or attendants should be instructed in the correct position to hold the patient. Motion-restricting devices should be utilized wherever possible.

The third determining factor of X-radiation exposure is the technique employed and the procedure followed. Some of the specialized procedures require extra precaution. Angiographic procedures that are now so popular are potential threats because of the multiple exposures of high intensity. Secondary radiation in retrograde urethro-cystography in which the injection of contrast medium must be made while exposure is in progress, is a risk to the urologist. Two of the greatest hazards, both to radiologist and surgeon, are the setting of fractures and the removal of foreign bodies. Provided adequate precautions are taken, no radiation injuries, either acute or chronic, should result from any diagnostic radiographic procedure.

A physician's hands and health are priceless and their protection is cheap.

Hazards other than those of radiation should be included for completeness. The range of kilovoltages used in X-ray equipment is very high. Therefore, there is always a danger of accidents resulting from electrical shock. However, present-day equipment is well insulated and grounded, reducing this possible danger. The use of inflammable anaesthetics should be avoided during X-ray work, particularly fluoroscopy. There is always a potential danger when the following anaesthetics are used: ether, ethylene, ethylchloride, and cyclopropane. If circumstances demand the use of fluoroscopy, satisfactory ventilation should be provided to decrease the concentration of the anaesthetic substance in the air. Spark sources should be eliminated by spark-free electrical switches and contacts, and adequate insulation.

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Radiological Localization of the Placental Site

W. R. R. Thursfield, D.M.R.

INTRODUCTION

Placenta praevia is a serious complication of pregnancy. The dangers of this condition can be considerably reduced if early and accurate diagnosis can be made. The necessity of vaginal examinations, with consequent risk of inducing serious haemorrhage, may frequently be avoided, if placenta praevia can be shown to be present. In patients in whom placenta praevia can be established, a long period of hospitalization can be avoided. The contribution of Radiology in the diagnosis of this condition is recent, but considerable progress has been made in the last few years. Advances in Radiological technique are largely due to improvement in X-ray apparatus, and it is now possible to demonstrate structure and change which were previously invisible.

Methods of Placental Localization

It is interesting to review the varied approaches which have been made to the problem of Radiological localization of the placental site.

1. *Direct Placentography*

Intravenous injection of an insoluble suspension of substances of high atomic weight has been used to opacify the liver and spleen in mice and guinea pigs. In some instances this has resulted in opacification of the placenta in addition. Unfortunately the substances, which had been used with success in experimental animals, have not so far proven satisfactory for use in humans. Further research may well produce a satisfactory non-toxic medium.

2. *Amniography*

Injection of one of the media customarily used for intravenous pyelography, into the amniotic sac, has been used to produce more precise delineation of the inner aspect of the uterine wall. By plain film technique, the outer contour of the uterine wall can be identified, but this method provides more precise identification of the localized thickening produced by the placenta.

This method has not become generally accepted, owing to the risk of inducing labour prematurely and to the risk of injuring the foetus.

3. *Intravenous Injection of Radioactive Sodium Salts*

An interesting method has been developed, employing Radioactive Sodium Chloride. Following intravenous injection, the latter can be detected in the placental sinuses by a Geiger Counter. The vascularity of the placenta results in a higher concentration of the isotope than is encountered elsewhere. Accurate localization of an anteriorly situated placenta has been possible with this technique, but it has not been possible to identify the lower limit of the placenta with reasonable accuracy, when the latter is implanted on the posterior uterine will.

The mother and foetus are subjected to no more radiation than is administered when obtaining a single Radiograph of the pregnant abdomen.

4. *Soft Tissue Radiography*

With the development of more powerful X-ray equipment, much attention has been devoted to high kilovoltage technique. I believe that for demonstration of soft tissues, and particularly of placental calcification, low K.V. is essential.

A brief explanation of the technical factors involved should be of assistance in understanding the advantage of low K.V. technique.

The differences in density between various soft tissue structures is relatively slight. This difference, as demonstrated by blackening on an X-ray film, can be exaggerated by employing an X-ray beam of low penetrating power, e.g. the majority of the beam, passing through fat, will reach the X-ray film and produce an area of blackening, while slightly denser muscle will arrest a high proportion of the beam and produce a relatively translucent area, which stands out by contrast. If high kilovoltage is employed the X-ray tends to penetrate all the structures and the difference between the shadows is less striking.

The reason that high kilovoltage is employed is that it is relatively easy to obtain a fairly satisfactory film. Since most of the X-rays reach the film, the exposure time is short and the exposure factors do not have to be judged so precisely.

The technical disadvantages of low K.V. technique can be largely overcome in the P.A. and A.P. views of the abdomen by the application of compression.

A wide compression band, extending from the pubic symphysis to the fundus of the uterus, is used to decrease the thickness of the soft tissues. This manoeuvre is surprisingly well tolerated by the vast majority of patients and is an indispensible factor in obtaining radiographs of a quality that allows identification of change hitherto undetected.

On the P.A., A.P. and lateral views of the abdomen, it is possible to demonstrate the outer contour of the uterus and the subcutaneous layer of foetal fat, which stands out as a dark line. Where the foetus is in close contact with the uterine wall these two outlines are close together. If a normal quantity of liquor is present it is possible to identify the placenta by outline of an increase in the distance between these boundaries.

It was originally thought that the placenta was almost always predominantly on the anterior or posterior uterine wall.

It is certainly true that the placenta is most easily demonstrated on views obtained with the patient in the lateral decubitus position. However, development of the prone P.A. projection and the A.P. supine view has resulted in more frequent identification of the placenta in whole or part on the lateral walls.

Of particular importance, in these views of the abdomen, is the identification of placental calcification. This has been demonstrated in utero in approximately one-third of all cases examined after the 32 weeks by several authors. It provides an invaluable check and on many occasions calcification may outline the entire extent of the placenta. Calcification is visible as a faint granular shadow and the frequency with which it is detected is a good index of the quality of the radiographs. The frequency with which it is detected is much higher with low K.V. than with high K.V. technique.

Identification is most often possible on films which have been well exposed and which are viewed in front of a source of intense illumination.

In addition to information, which is of value in placental localization, the foetus is particularly well shown and estimation of foetal maturity and detection of foetal abnormalities is facilitated.

5. *Displacement of the Presenting Part in Relation to the Pelvic Inlet*

A further method of evaluation is obtained by study of the A.P. and lateral views of the pelvis. It is frequently possible to identify the soft tissue shadows of the uterine wall, laterally and posteriorly, if films of good quality are obtained. Since these views must be obtained with relatively high K.V. technique in order to penetrate the pelvis, a small cone and accurate centering are essential.

The projections are obtained with the patient standing. This tends to produce engagement of the presenting part and ensures that displacement occurs in spite of the effect of gravity.

It was often possible to show that the distance between the outer aspect of the uterine wall and the presenting part is sufficiently small to exclude extension of the placenta onto the lower uterine segment. In addition, the relationship of the presenting part to the sacral promontory, pubic symphysis or either side wall of the pelvis, can be shown. An eccentric relationship between the foetal head or breech and the pelvic brim, if in conjunction with the demonstration of the placenta in the appropriate position in views of the abdomen, is strongly suggestive of placenta praevia. If the placenta is on the posterior wall, and the presenting part is not in close proximity to the sacral promontory, it may sometimes be necessary to obtain a lateral view with the patient reclining. This will show whether the gap can be closed when gravity is brought into play.

6. *Cystography*

In conjunction with the above technique the use of contrast medium in the bladder may provide additional information. The medium employed can be either opaque or radiolucent. Sodium iodide solution is commonly used in the former instance while air is an alternative medium which has certain advantages.

As mentioned above, identification of the intra-pelvic portion of the uterine wall provides a satisfactory means of assessment. However, while the uterine wall can usually be seen on the posterior and lateral aspects, definition is usually less satisfactory anteriorly. Cystography is therefore of help in outlining the anterior boundary of the uterus, since the bladder lies in close proximity.

This method is of course one of the oldest means of investigation. Used alone, findings may frequently be misleading. Used in conjunction with other methods it may provide one more link in the chain of circumstantial evidence.

Cystography is of particular value in suspected anterior placenta praevia. Since a partially full bladder may closely mimic anterior placenta praevia it is also of value in ensuring that an increased gap between the presenting part and the pubic symphysis is not in fact due to a distended bladder.

7. *Retrograde Femoral Arteriography*

The development of percutaneous puncture of the carotid artery has made injection of the femoral artery a relatively easy procedure in practised hands. Following puncture of the femoral artery, tourniquets around both thighs are inflated. Forcible injection of contrast medium results in retrograde flow of the medium into the internal iliac artery on the side of injection and frequently the medium crosses to the contra-lateral internal iliac artery. A film obtained at the end of the injection followed by a second film after an interval of approximately two seconds, provides a graphic demonstration of opacification of the uterine circulation. Filling of the placental sinuses offers a valuable means of localizing the placenta in selected cases.

I must stress that this technique is unnecessary in the great majority of cases. It may be employed when placenta praevia is suspected prior to the 28th week of pregnancy, and when simpler methods have failed, as they can be expected to do in a high percentage of cases.

Retrograde femoral arteriography may also be of help where multiple pregnancy, hydramnios or presentation other than vertex or breech are encountered.

Method Used at the Victoria Hospital

Initially P.A. and lateral views of the abdomen are obtained. The placenta is identified by by the means mentioned above and precise localization may occasionally be obtained from these films alone. However, A.P. and lateral views of the pelvis are usually obtained in addition to ensure beyond doubt that the placenta does not extend onto the lower uterine segment. The views of the pelvis are used to confirm that the placenta does not enter the pelvis at the point where this could be anticipated following identification within the upper uterine segment. For example, if the placenta lies on the anterior uterine wall a cystogram will be performed to investigate the anterior aspect of the lower segment.

Placental calcification is always sought and often changes a relative certainty into an established fact.

Accuracy of localization must depend on the use of as many methods as can conveniently be combined. This allows cross checking of the findings and rejection of a single finding which taken alone could be misleading.

Radiological localization of the placental sites allows accurate detection of placenta praevia or exclusion of this condition in a high percentage of cases. It is in fact frequently possible to detect placenta praevia before the onset of bleeding and to detect minor degrees of placenta praevia where bleeding has not occurred and does not subsequently appear. Such cases are frequently referred as "high head" problems. Placental localization is therefore desirable in cases where the head cannot be made to engage and where there is an unstable presentation, even in the absence of bleeding.

Placental localization becomes increasingly accurate in later stages of pregnancy. Accurate localization can often be obtained as early as the twenty-eighth week. By the thirty-second week there are few cases in which the placenta cannot be localized.

Relationship Between the Placental Site and Position of the Foetus

In the presence of breech presentation there is a high incidence of fundal-cornual implantation of the placenta. This is such a frequent finding that the possibility that fundal-cornual insertion is a cause of breech presentation must be considered.

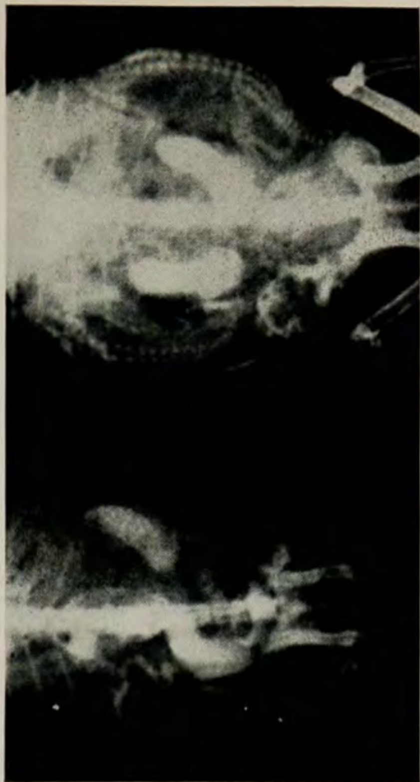
The foetus rarely lies with the dorsal aspect against the placenta. However, this does not imply that the ventral aspect of the foetus always faces the placenta and the ventral of either lateral aspect is usually in apposition. When the placenta lies on the posterior uterine wall it would appear logical to expect anterior position of the occiput. This is borne out statistically. Conversely when the placenta is inserted on the anterior uterine wall, posterior position of the occiput is 2 to 3 times more common. However, spontaneous rotation usually occurs and persistent occipito-posterior is unlikely to be encountered unless there is a combination of anterior implantation of the placenta with an anthropoid pelvis.

When gross placenta praevia is present the presenting part is most unlikely to engage and in my experience, if the head is well engaged, placenta praevia has not been encountered.

Differential Diagnosis

1. *Bladder*

Placenta praevia may be simulated when the placenta is situated anteriorly and the presenting part is displaced upwards by a distended or partially filled bladder.



(b)

(a)

Figure 1

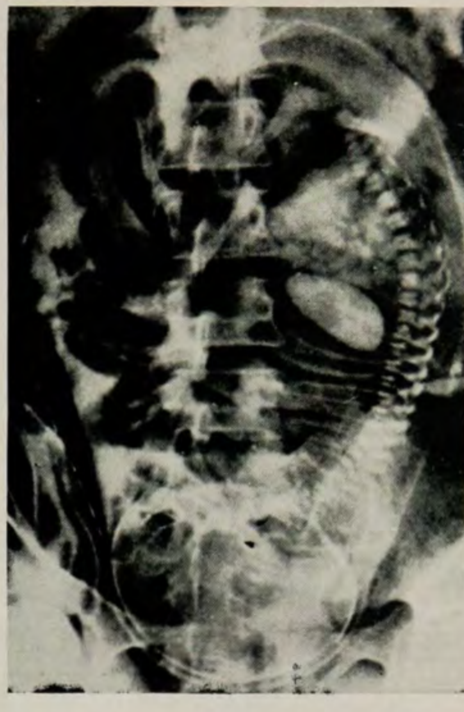


Figure 2

Figure 1. Views of a pregnant guinea pig obtained one and three and a half hours after intravenous injection of Angiopac. Two placentae have been demonstrated. Increased density of the placentae is shown at the second examination.

Figure 2. Amniography. Contrast medium is shown within the amniotic cavity. The dotted line shows the estimated position of the inner aspect of the uterine wall, medial to which is the fusiform filling defect produced by the placenta. Note that contrast medium is present within the foetal stomach and small bowel.

Figure 3. Recumbent lateral projection of abdomen, showing soft tissue shadow of the placenta, which is inserted on to the anterior uterine wall. Placenta confined to the upper uterine segment.

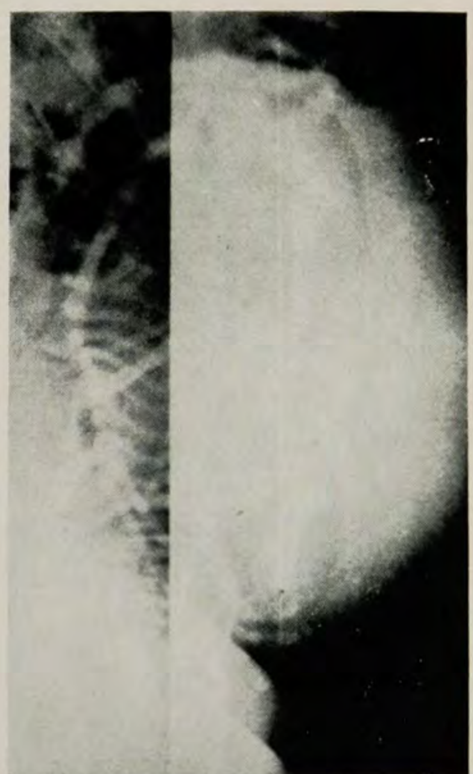


Figure 3

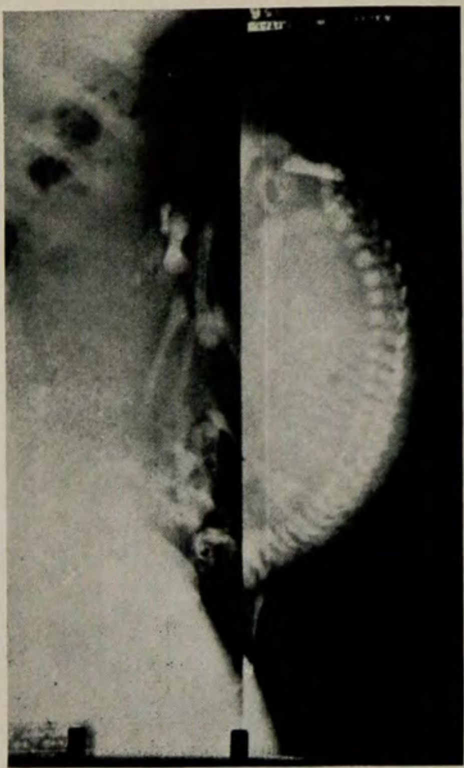


Figure 4

Figure 5

Figure 6

Figure 4. Recumbent laterial view of abdomen showing the placenta on the posterior uterine wall.

Figure 5. Selected portion of a P.A., prone, projection showing the placenta low on the right lateral uterine wall. A minor degree of placenta praevia was present in this case.

Figure 6. Selected area from a P.A., prone, projection. Thin line of placental calcification showing the inferior extremity of the placenta which lay partially on the right lateral uterine wall and could be seen to extend to the fundus of the uterus, by virtue of calcification.

Figure 7

Figure 8

Figure 7. A.P. projection of pelvis obtained with the patient standing. This film shows that the foetal head is central and engaging. The soft tissue shadow of the lateral uterine wall is clearly shown, and is of equal width, and normal thickness on both sides.

Figure 8. Lateral projection of the pelvis, obtained with the patient standing. The soft tissue shadow of the posterior profile of the uterus is well shown. The thickness of the uterine wall can be determined where it overlies the foetal skull, and the narrow gap between the foetal skull and the sacral promontory is further evidence that the placenta could not be extending on to the lower uterine segment posteriorly in this case.

Figure 9. Lateral View of pelvis obtained with the patient supine. In this case the views of the abdomen showed the placenta lying low on the posterior uterine wall. To confirm that the placenta was extending into the pelvis, this view was obtained to show whether or not the foetal head remained displaced away from the sacray promontory, in spite of the effect of gravity.

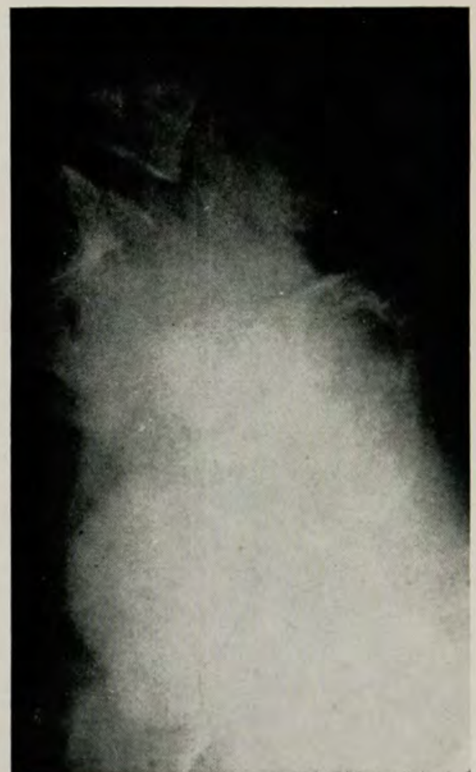


Figure 9

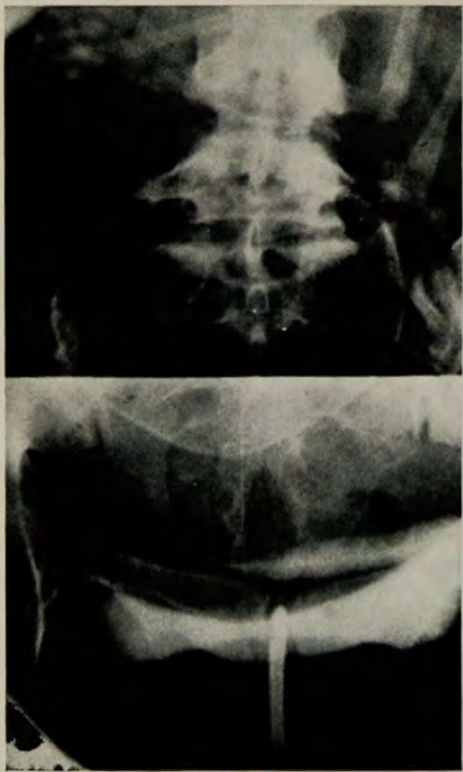


Figure 10

Figure 11

Figure 10. A.P. view of pelvis, obtained with the patient standing, and with contrast medium introduced into the bladder. This film shows considerable increase in the distance between the superior aspect of the bladder and the foetal head, due to gross anterior placenta praevia.

Figure 11. Standing lateral view of pelvis with contrast medium in the bladder. Other films had shown that the placenta was inserted onto the anterior uterine wall and was extending towards the pelvic inlet. The supra-pubic portion of the bladder is displaced away from the foetal skull by the lower extremity of the placenta which can be seen to approach the brim of the pelvis but does not extend into the pelvic cavity.

Figure 12. Retrograde femoral arteriography. Contrast medium is shown within the iliac arteries on the right side and has also entered the iliac vessels on the left side, due to retrograde flow into the distal portion of the aorta. The placenta is shown to lie within the fundus and the lower extremity is well above the junction of the upper and lower uterine segments. Note the irregular opacities produced by contrast medium within the placental sinuses.

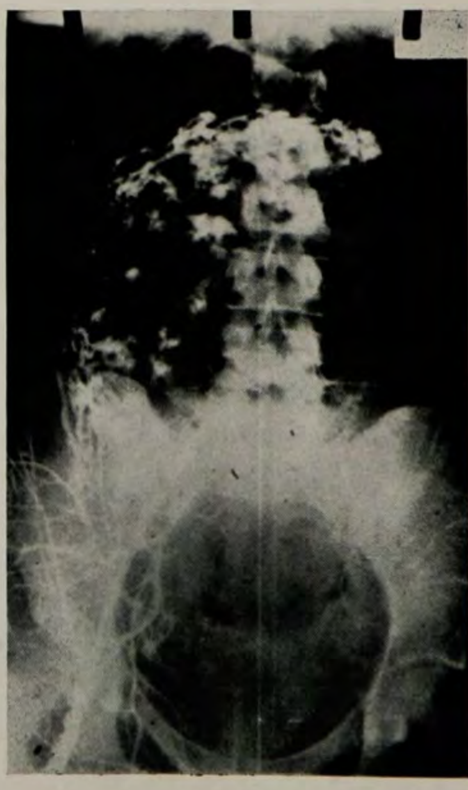


Figure 12

This error can be avoided by routine evacuation of the bladder immediately prior to X-ray examination or preferably by introducing contrast medium into the bladder which provides definite information re the degree of vesical filling.

2. *Faeces*

Distention of the rectum and pelvic colon is an occasional cause of displacement of the presenting part. The films will usually show an abnormal accumulation of faeces in the pelvis and in doubtful cases the patient should be re-examined after evacuation of the bowel.

Opaque material within the bowel may mimic placental calcification. However, this is rarely a serious problem.

3. *Pelvic Tumours*

On rare occasions, the diagnosis can be made when the radiographs reveal the typical appearance of a calcified fibroid, an ovarian dermoid cyst or a bony tumour such as an osteochondroma.

Other tumours may be suspected when there is absence of continuity between the placental shadow and the site of the presenting part displacement.

4. *Placenta*

In exceptional cases placental abnormality might cause an error in diagnosis. For example, placenta succenturiata. This error might be avoided by the use of retrograde femoral arteriography should the succenturia lobe be suspected by clinical investigation or possibly by virtue of discrepancy between the various X-ray findings. Vasa praevia cannot be detected per se.

5. *Foetal Abnormality*

Placental calcification may be mimicked by calcification within a foetal thyroid tumour or calcification in association with meconium peritonitis. Differentiation depends on correlation between the apparent site of placental calcification and other X-ray evidence of the placental site.

Further foetal abnormalities which might produce conflicting evidence are meningocoele, sacro-coccygeal tumour and cystic hygroma.

6. *Uterine Abnormalities*

Blood clot produced by accidental haemorrhage or an intramural fibroid may produce a localized thickening of the uterine wall which may cause difficulty in interpretation.

7. *Cephalo-Pelvic Disproportion*

Precise localization may be difficult if gross pelvic deformities are present. Again, error is most likely to be avoided when numerous criteria are employed in evaluation and apparent displacement of the presenting part away from a portion of the brim may be shown to occur in a different situation from that shown to be occupied by the bulk of the placenta.

Common causes of coin lesions of the lung include solitary metastases, tuberculoma, hamartoma and bronchogenic carcinoma.

Advances in X-Ray Contrast Media

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INTRODUCTION

The field of diagnostic radiology is continually widening. For a good part, this is due to better contrast media which have become available in the course of time.

It is customary for a manufacturer to invent a trade name for his contrast medium. Without further explanation such a name only too often is of no help in understanding what the compound means. The need for such action is appreciated, yet it must be regretted that the benefit to the manufacturer is not paralleled with a benefit to the medical profession. One realizes that it would be difficult to find a better way to designate these compounds, many of which have a complicated chemical structure. Yet, it seems justified to point to the need for a nomenclature that would enable the average reader to classify the material in question. As it is now, only people who are fully familiar with the literature are able to evaluate the contrast media—and even then not all of them.

In this paper a picture will be drawn of the more recent additions to the list of contrast media, with some background to explain why they were created. In many instances products of different manufacturers that serve the same purpose are compared. The writer regrets that sometimes he must appear very partial. If a definite recommendation is given this was never done without careful study of the publications on the subject. No details of the use of contrast media are given, as this would comprise the greater part of the field of diagnostic radiology. At the end a list of synonyms is given to be of help to the student who is interested in the literature.

PRINCIPLES

X-rays, when passing through the human body on their way to the film are attenuated in the material of which the body is composed by absorption and scattering. The attenuation is different for different thicknesses of the part, and also is dependent upon the atomic composition of the material. The absorption per atom increases with the atomic number in a rather complicated way. Very generally speaking, it occurs at a rate that is higher than the first power of the atomic number. As the atomic composition is different in different parts of the body, the X-rays emerging from the body geographically have different intensities and influence the X-ray film proportionally. If we look at the different substances of which the body is composed, we can say that the beam, where it passes through densely calcified bone, suffers the greatest attenuation.

All the material that has a high water content, for practical purposes, shows the same rate of absorption. (This absorption is much less than in calcified bone.) Consequently, a beam emerging from a body composed partly of muscle, tendon, cartilage, blood, milk that has been ingested, exudates, transudates, secretions, excretions or tumours does not show geographical differentiation in intensity and therefore causes a homogeneous greying of the film.

However, if we study a flat film of the abdomen we see some differentiation. This is partly the result of fat deposits between the organs. Fat has a greater

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transparency than water containing substances, owing to the proportionally greater carbon content. Carbon has a lower atomic number than oxygen. Secondly, the differentiation is caused by gas filled spaces in the bowel, through which the rays have passed without appreciable interference.

Cancellous bone and lung parenchyma occupy intermediate positions relative to the proportions of calcium versus water-containing soft matter or the latter versus air spaces, contained in them. The detail of the X-ray picture is insufficient to see the small particles separately.

Owing to this state of affairs, the doctors who were mainly interested in the skeleton, from the beginning of the Roentgen-era, received a great satisfaction from the study of their X-ray films. But those who attended patients with diseases located in the soft tissues, were disappointed. It is true that changes in the contours of the picture of the air in the lungs is of help in diagnosing diseases of heart, lungs and other neighbouring parts, and that unusual pattern of the abdominal gas has a meaning. Study of the fat deposits normally present between organs can tell us about internal displacements. But for the great majority of diseases of the soft tissues, the plain X-ray picture is of little help.

Gastro-Intestinal Contrast Media

Rather soon after the discovery of X-rays, man's ingenuity prompted him to create X-ray differentiation amongst the soft tissues, when nature had not provided it. It is believed that it was Rieder, a German Roentgenologist, who was the first to give to a patient, with gastric complaints, a mixture of food and the insoluble salt of a metal with a very high atomic number. Since such a mixture is very poorly transparent to X-rays, he was able to follow it on its course through the body by its X-ray shadow. Although in this way he did not get a picture of the stomach and bowel themselves, he did get a picture of the fluid cast of these organs which was quite valuable.

The disadvantage of this kind of massive filling of a stomach is that the abnormalities become visible only as irregularities of the outline, when the rays hit them tangentially. Especially with pictures, but even with fluoroscopy, there is the risk that a lesion will remain undetected, unseen because of its location on the margin. Because we are interested in finer details of the surface, we would like to have the contrast medium spread like a coating over the surface, with the center of the lumen transparent. If we have a medium that adheres very well to the mucosa, and if there is sufficient gas in the stomach, this requirement might be fulfilled. The mixture of finely powdered barium sulphate and water that is frequently used for the "barium meal" is not very suitable for this purpose. Contrast media have been developed that have better adhering properties made possible by addition of special substances. The best results are obtained when the additions are of the carboxymethylcellulose type. These do not stimulate the mucosa of the stomach to secrete digestive juices, or at least less than those containing stabilizing ingredients of the albumen or starch type. If juices are secreted by the mucosa, a contrast coating that might have been formed on the mucosa will be lifted up and floated away.

The problem of coating the mucosa becomes greater when the mucosa is irritated or inflamed. In that case there is hypersecretion of mucus and juices even without a meal. Also the best media are only partially effective in such a case. Moreover, the fluid that fills the stomach is not homogeneous. It consists partly of contrast fluid and partly of a slimy gastric juice. The two do not mix readily and the fluid resembles curdled milk. The curdling seems to be worse in the case of a simple barium sulphate-water suspension, than for one in which protective colloids are present. Part of the curdling is probably the result of the mechanical difficulty of mixing mucous fluids. We have to confess that rather little of what really happens is known, mainly because too many factors are involved and these factors vary from case to case. This is best illustrated by the fact that the appearance of the same brand of contrast medium in the same region of the small bowel may be quite different at a recheck of the case a few days later.

If a coating cannot be obtained, or if the section of the stomach to be studied is completely filled with fluid, we have to use various degrees of compression ("dosaged compression") of the abdomen. In this way, we bring the anterior and posterior walls of the stomach just close enough together so that the barium mixture becomes transparent and, being of unequal thickness in places, causes a relief picture.

Obviously it is essential that the mixture per se casts a homogeneous shadow. The contrast media of the carboxymethylcellulose type mix easier with mucous fluids than a plain barium sulphate suspension in water and are therefore preferable. Other media that have been tried are silicone-water-barium sulphate mixtures which have about the same value as carboxymethylcellulose mixtures, and a stable colloidal suspension of barium sulphate that mixes well with gastric secretion without flocculation. Finally, a suspension of barium sulphate in oil that would not mix with but displaces the secretion. In an attempt to improve the results, many people have used microcrystalline barium sulphate. Experiments showed that the optimum is achieved with the fineness of U.S.P. Barium Sulphate. More work must be done on these media before they can be generally accepted.

If none of these improved gastric contrast media is available, or if even these fail, a simple, old technique can be used. Have the patient take a suspension of barium sulphate in water of as high a consistency as he can reasonably swallow. That is a consistency of thick cream, one in which a spoon does not fall over when put in vertically. Due to its very high specific gravity (2 or more) this mixture will quickly sink to the lowest spot of the stomach, displacing the hypersecretion with which it does not mix. With suitable positioning of the patient, to move this heavy mixture to the required spot of the stomach, and with correctly adjusted compression, the most minute details can be brought out.

The success of the barium meal (and of the barium enema) led to attempts to visualize other cavities with contrast media. It was soon realized that salts like barium sulphate can only be used in places where the elimination is as easy as in the bowel. If they are not evacuated they set up a foreign body reaction. This excludes their use for example in the urinary and genital tracts. More suitable media for the examination of such spaces were found in sodium bromide and sodium iodide, although their use is accompanied with side reactions. Some of the latter are caused by the toxicity, which varies in different persons, some by the need to use concentrated solutions which are very hypertonic. The following consideration explains why the bromides are much inferior to the iodides and were soon abandoned. Each atom of iodine produces a much denser shadow than an atom of bromine which is lower in the rank of atomic numbers. Accordingly a much more hypertonic solution of sodium bromide has to be used than sodium iodide solution to produce the same shadow. Until the year 1930 the only way to produce a pyelogram was with sodium iodide solutions, injected retrograde through ureteral catheters. As the objection to sodium iodide is the result of the iodine being in the ionic form, substances containing iodine in closely bound organic form were tried as contrast media.

Media for Bronchography

The first of these compound used was Lipiodol, which is non-water soluble and so is not eliminated any better than barium sulphate. However, the foreign body reaction caused by it is less severe than with barium sulphate. Lipiodol is a pharmaceutical preparation for protracted iodine therapy that was known to be well tolerated when injected into muscle. In 1922, Sicard and Forestier successfully used it to produce bronchograms. It is a clear, yellow, very viscous oil, that contains a large amount of iodine (40% of the weight is iodine) and accordingly casts an excellent shadow even in small amounts. The iodine is closely bound in the molecule of the fatty acid of the oil, and is not split off in the body, unless the Lipiodol is digested in the gastrointestinal tract. Accordingly it is only slightly irritating to the tissues. For bronchography it has just about the right viscosity, coating the mucous membranes with a thin layer, if there is not too much mucus in the bronchi. It has a very unpleasant taste. When introduced into the trachea and bronchi it creates a cough reflex, in the same way as a quantity of mucus does and accordingly it is necessary to anaesthetize them. The degree of this anaesthesia is important, because when it is too shallow the patient coughs the medium up before the examination is completed. Anaesthesia, which is too deep, seems to be the main reason that Lipiodol sometimes flows out too far into the periphery of the air passages without being checked, even passing into the alveoli. Lipiodol in the alveoli elicits no cough reflex, and the absorption through the mucosa is extremely slow. Examination of lobes, removed at operation sometime after bronchography with Lipiodol, shows marked reaction to the oil in the form of granulomatous infiltration, similar to that in lipoid pneumonia. The shadow of the contrast oil in the alveoli and occasionally in poorly emptying bronchiectatic cavities remains visible for months and years, causing difficulty in the interpretation of eventual repeat examinations, and disturbing the peace of mind of the responsible doctor.

Some years ago when we had become quite familiar with water soluble organic compounds that contain a large percentage of iodine (those originally used in urography and to be discussed below) attempts were made to introduce those compounds into the bronchi. As they are readily absorbed through the intact membrane we do not have to worry about late damage. Because these media are as fluid as water they do not adhere to the mucosa of the bronchi. In order to obtain the desired coating (total filling obviously is impractical) the media were mixed with substances like carboxymethylcellulose which gives the required viscosity. In the hands of many investigators the pictures were quite satisfactory and as expected the chest was clear of contrast shadows in a very short time, a few hours at the most. However, the mixtures proved to be extremely irritant to the bronchi, and it is necessary to anaesthetize the trachea and bronchi very thoroughly to keep the media down long enough for the examination to be completed. The reason for this irritation is not clear. The media belonging to this group are amongst others, Umbradil Viscous B, Perabrodil M, Methoceldiodrast, Diodone Visquese and Joduron B.

This method seemed to be a step forward, considering the disadvantages of Lipiodol. The mixtures do not have a bad taste, like Lipiodol, which might be weighed against the greater discomfort of the violent cough reflex. However, pathological examination of lobes of lung, removed surgically after these bronchographies, showed that we had only plastered the grave. In many cases, granulomatous masses were found as a foreign body reaction against the carboxymethylcellulose when this entered the alveoli. The carboxymethylcellulose is not absorbed like the iodine compound, but has to be eliminated by the bronchi. This seems to be as difficult as it is with Lipiodol. As very deep local anaesthesia is necessary to make these bronchographies possible, alveolar filling may occur more often than with Lipiodol. But so far as I know, this has not been evaluated statistically.

The latest attempts for a better medium are Dionosil aqueous and oily. The first is a mixture of sparingly water soluble derivative of Diodrast (a substance to be described below) with a viscous vehicle, i.e. carboxymethylcellulose. Because of the low solubility of the iodine compound the elimination of the shadow producing substance from the bronchial tree is slower than when the readily water soluble substances are used. Very rapid absorption sometimes had been felt to be a disadvantage. The shadow of Dionosil-aqueous disappears in a few days, four at the most. However, according to some writers the irritation of the bronchi caused by Dionosil-aqueous is even worse than with the mixture of the Umbradil Viscous B type. As this requires maximal anaesthesia the danger of alveolar filling with the above raised objections seems to be very real. The vehicle is carboxymethylcellulose as before, with a "wetting agent".

Dionosil-oily shows little irritation of the bronchi, gives good pictures, but one writer mentions alveolar filling in about half of his cases, which would seem to be very undesirable. The oil of the mixture almost certainly will remain even if the contrast shadow disappears.

Summing up, we have to admit that a really satisfactory medium for bronchography has not been found yet. All those available present a risk because they can cause granulomas. The special objection against Lipiodol, that quantities left behind could cause trouble with the interpretation of repeat examinations, seems to have been somewhat overstressed. If careful technique is used, and only small quantities are instilled, the rather infrequent alveolar filling which occurs in such small areas, is of no real significance. It would seem that Lipiodol still is the most desirable material, just because alveolar filling remains visible to remind the doctors that bronchography still is afflicted with disadvantages in the long term.

It is hoped that research for a better medium will be pursued energetically.

Media for Cholography

In 1924, Graham and Cole found an entirely new way to produce X-ray contrast in an organ, when they injected the organic bromine compound tetrabromphenolphthalein intravenously. They knew that tetrachlorphenolphthalein is excreted selectively by the liver into the bile. They reasoned that the corresponding bromine and iodine compounds also would be excreted in the bile and that the bile might become sufficiently opaque to X-rays to become visible on the film. They knew that the iodine analogue would be better than the bromine, but the first iodine products were too toxic and they had to use bromine. Now the concentration of tetrabromphenolphthalein (as well as the tetraiodo-) in the liver bile is not high enough to produce the desired shadow. But they had luck — at least one can doubt that they had foreseen this as they do not mention it in their first publication—because the gall bladder, when taking in the liver bile for storage concentrates it at the same time. This raises the concentration of bromine or iodine sufficiently for X-ray visualization. Until very recently, no contrast media have been found that can cause an iodine concentration in bile sufficient for direct visualization.

While this method of excretory cholecystography, as it was called, was a great step forward, it cannot be denied that it had disadvantages. The contrast medium is poisonous and must be injected very slowly into a vein, preferably in two portions half an hour apart. If any of it (even a drop) is deposited outside the vein, it causes a necrosis. Not infrequently thrombosis of the vein occurs. The solution must be prepared from the dry salt immediately before injection. Accordingly, attempts to give the medium orally were tried, and although being rather unpleasant, this method gained preference over the intravenous route.

This method of visualizing the biliary tract came into more general use when different drugs, which are also excreted in the bile but which are far less toxic and which produce even better shadows, became available. They are all media that have to be taken by mouth and the best known of these is Priodax. This has been in use for many years and only a few years ago has been superseded by still better oral media: Telepaque and Teridax. While Priodax contains two atoms of iodine per molecule, the last two mentioned media contain 3 atoms and cast a proportionally heavier shadow. Rather large amounts of the media have to be taken — several grams, and it is not surprising that side effects in the nature of nausea, diarrhoea, etc., are experienced. These side effects practically limit the amount that can be taken. According to publications, Teridax is 2½ times more toxic than Telepaque. Although one can occasionally increase the customary dose of about 3 grams of Telepaque even to double the amount, one would not like to do this with Teridax. With the higher dose of the medium, the pictures obtained present more contrast. This may be of importance in overweight people and make possible visualization even if the gall bladder functions poorly.

Not until quite recently has a compound been found that can replace tetraiodophenolphthalein for the intravenous route of administration. This route has the advantage that the results of the examination are known in a matter of a few hours or less. The oral method requires generally 12-14 hours. Non-filling of the gall bladder has more significance in the case of the oral route, because with the intravenous route there can be no doubt about the absorption into the blood. Notwithstanding these advantages the intravenous route was only rarely used (because it was too cumbersome) until the advent of the new medium cholografin. Cholografin is a medium that contains 6 atoms of iodine per molecule, yet it has an amazingly low toxicity. If injected per chance paravenously only slight irritation occurs, and no venous thrombosis results from the injection which often occurs with tetraiodophenolphthalein. The concentration in the bile becomes very high. It may reach 30 to 100 times that of the blood. It becomes so high that the liver bile in the hepatic ducts casts a sufficient shadow to become visible. This is seen in pictures taken about 20 minutes after the injection. This already strongly iodine containing bile is further concentrated in the gall bladder, which is examined 1 and 2½ hours after the injection, and produces a dense shadow. (Gall stones may become hidden in this very dense shadow and therefore the penetration of the X-rays should not be too low.) Finally around 30 minutes after a fat meal this dense gall bladder bile gives very good pictures of the common duct when passing through it.

But even after the gall bladder has been taken out, the pictures of the common duct are reasonably good. The importance of this good visualization of the common duct can hardly be overestimated. This duct always has been one of the most inaccessible for every investigation (even during surgery) and here we have a method that seems to assure the diagnosis of stone in the common duct (also after cholecystectomy) or of processes outside the duct displacing or compressing it, and to promise insight into the normal and morbid physiology of the common bile duct. Studies on the influence of medication on the sphincter of Oddi have been undertaken and one investigator already has brought up a new concept, "biliary dyskinesia", as a result of his studies (Am. J. Med. Sc. 227:372).

Fulton (Am. Journ. Roent. 72:671) states: "Visualization of the gall bladder alone (cholecystography) no longer constitutes an acceptable study of a patient with symptoms referable to the biliary tract. The entire biliary tree must be visualized."

Intravenous cholography is contraindicated in cases of long standing jaundice because good pictures cannot be expected. The bromsulphalein test enables us to decide whether to do or not to do the examination. If more than 30% is retained by the liver in 45 minutes the common duct is usually not visualized with cholografin.

In what cases should we use the intravenous, in what cases the oral route?

If the result of the examination should be known in the shortest possible time, if a cholecystectomy has been done, or if one is principally interested in disorders of the bile ducts the intravenous route should be used. In all other cases it is better, because it is easier for the patient, to begin with the simple "office" procedure of oral Telepaque administration and pictures after about 12 hours. If the gall bladder is not visible by this method, or if the spiral and common ducts cannot be visualized, it is necessary to follow with intravenous cholografin to obtain the desired information.

Media for Excretory Urography, Arteriography, Venography, Arthrography

There is still another group of contrast media that contain iodine in organic form. These media are easily soluble in water and can take the place of sodium iodide, mentioned above, over which they have the advantage of being less toxic and less hypertonic. The shadow producing agent in them is iodine. As in the media for cholography, the iodine is so firmly bound in the organic molecule that none of it is split off in the body. The media are excreted in toto in the urine and feces. In the course of time the quantity of iodine contained in each molecule was increased from one atom to two and three, with considerable increase in contrast power.

The first of these compounds to be used was Uroselectan (Iopax in this country), a name that was chosen to denote that it is excreted selectively in the urine. The history is interesting: Swick from New York, at that time (1929) working in Germany, had the idea that this substance, synthetized by Binz and Raeth for selective chemotherapy of the urinary tracts, was promising as an X-ray contrast medium. The substance has a low toxicity and several grams of it can be injected intravenously without danger. It then is excreted rapidly into the urine and the iodine concentration in the urine becomes sufficiently concentrated to produce a X-ray picture, as Swick soon showed.

The new method, called excretory or intravenous pyelography, or more generally excretory urography, has the advantage over retrograde pyelography that no cystoscopy is necessary. However, at first, Uroselectan was not always perfectly purified and considerable side reactions occurred with the injection. A few cases resulted in death and it was doubtful whether this method was an improvement. Also the iodine concentration in the urine often was far inferior to that with retrograde pyelography, with correspondingly poorer pictures.

Within a few years better media of the same nature became available, which were better tolerated and gave more contrast in X-ray pictures. They were: Uroselectan B, Perabrodil, Neo-Iopax and especially Diodrast. These contain 2 atoms of iodine per molecule, against one atom in Uroselectan. With the advent of these new media came the possibility of visualizing arteries and veins, for the following reasons: Because of the frequency of side reactions the injection of Uroselectan had to be done very slowly (5 minutes for 20 millilitres of the solution). This was quite compatible with urography, where the picture with optimum contrast is taken about 20 minutes after injection. It, however, did not allow a sufficient concentration of the medium in a functioning artery, to produce a picture. Media like Diodrast are so well tolerated that they can be injected as fast as the bore of the needle will allow. Every blood vessel that is accessible by puncture can be visualized — and has been visualized.

The ease with which Diodrast and others generally are tolerated should not let us forget that side reactions and even serious accidents may also occur with them. The reason for these reactions is not clear. For a long time they have been supposed to be allergic reactions. One writer who investigated this statistically found that among allergic people the number of reactions is about double that of among non-allergic ones. However, this means that we will find the majority of reactors among people without a history of allergy, the number of people with a history being only 10-15% of the population. Taking a history to find allergic disposition and doing the customary intracutaneous or eye tests with the media cannot help us very much. Several writers deny that these tests have any value and a very recent publication states: "Secondary reaction of contrast media injected in the blood stream is not of allergic nature".

The only way to play safe under these circumstances is to do a trial run with a very small amount of the medium. This should be done early, before the injection, so that late reactions can be observed. For arteriography, especially when injection of large amounts is expected, the advice is given to inject 1 or 2 millilitres intravenously the day before.

In the case of intravenous urography it is generally desirable to do not more than one venipuncture. The injection is done slowly and after the first few drops there should be a pause of at least 2 minutes. Because of the risk of the needle becoming obstructed by clot during this pause there is the tendency not to wait long enough. It seems advisable always to have a syringe with saline at hand to keep the needle open during these 2 minutes.

Even with these precautions in all cases of intravascular injection of these media apparatus for administering oxygen, and drugs to treat collapse and shock (norepinephrine or other sympathomimetic drug), urticaria-like rash (calcium gluconate), convulsions (soluble barbiturates, calcium gluconate), should always be at hand in the X-ray room. It will be understood that the administration of anti-histamine preparations, either before or after development of the reaction is considered of no value by many writers.

The media can and should be free from all non-organically bound iodine.

Poor concentration of contrast medium in the urine can be expected if the N.P.N. is over 40 or 45. In that case it is useless and inadvisable to try intravenous urography.

The latest developed contrast medium in this field, Urokon-sodium, deserves special mention because it contains 3 atoms of iodine per molecule and creates proportionally denser X-ray shadows for the same concentration as do the di-iodo compounds like Diodrast. According to the many publications that have appeared on Urokon-sodium since its recent introduction it is not more toxic than the others. It is supplied in ampules, containing solutions of 30, 50 or 70%. The 30% solution is intended for arteriography of the brain, and the first publications on it are favourable. It causes milder subjective complaints than 30% Diodrast (which is a rather low concentration to use).

In arteriography the medium is soon mixed with a large quantity of blood and diluted. It therefore, is advisable to use the 70% solution for injection.

Angiocardiography with the injection of a rather large amount of the 70% Ukron-sodium into vein (25 or even 50 millilitres) causes severe pain in the upper arm, owing to the hypertonicity of the solution. Injection of 5-10 millilitres of 1% novocain into the vein prior to the injection seems to be very desirable.

For urography many writers recommend the use of one ampule of 25 millilitres of the 70% solution. The strength of the solution seems rather unimportant in this case, providing a sufficient amount of dry weight of medium is injected. The dry weight of medium in an ampule of 70% solution is just right for the average person, i.e. 15 millilitres of the 70% solution per 1 square meter of surface area. As all the ampules of Urokon-sodium are 25 millilitres and few people would open up two ampules of 50% and discard part of the second one, it seems better to use 70% Urokon-sodium and inject it very slowly (that the blood may dilute it). As the amount of dry weight of the medium should be varied with the size of the patient, for smaller people 25 millilitres of 50% solution could be used.

In successful cases the iodine concentration in the urine is similar to that of customary retrograde pyelography.

One writer states that when he injected 70% Urokon-sodium (25 millilitres) he even got good urograms in cases of renal functional impairment. It would seem that according to this the limit for the N.P.N. could be raised, maybe to 60.

From the experience gained so far it would seem that Urokon-sodium is a definite step forward, although it does not constitute the ideal contrast medium for blood vessels because in greater concentrations it still is markedly irritating. The precautions in view of possible serious reactions should be followed as described for the other contrast media above.

Organography

All the different techniques, described above, result in some space in an organ, duct or vessel becoming radio-opaque. In a few instances it is possible to make the organs themselves opaque. This requires the selective absorption of a contrast medium into the parenchyma or into the finer elements of the parenchyma.

The only organ with which this can be done safely is the kidney. Shortly after the injection of the media for excretory urography, the kidney parenchyma has stored up enough of the medium to become much more differentiated from the perirenal fat capsule than it was before. If a tissue of a very different nature is contained within the kidney, like a tumour, this tissue does not absorb the medium selectively and shows as a defect.

The liver and spleen can be selectively visualized by means of Thorotrast. This is an opalescent fluid, containing thorium dioxide in very stable colloidal form. It has a high absorbing power for X-rays, because 40% of the weight is in the form of thorium, and thorium has one of the highest atomic numbers. When Thorotrast is injected intravenously the thorium oxide gradually is absorbed from the blood by the cells of the reticulo-endothelial system. As there are many of these cells in the liver and spleen, these organs become radio-opaque if the quantity in-

Best Known Trade Name	Official Name and Trade Name Synonyms	Iodine Content	Chemical Composition
MEDIA FOR BRONCHOGRAPHY			
Lipiodol		40%	Iodine added into unsaturated fatty acid
Pantopaque			Ethyliodophenyl Undecylate
Dionosil Oily		25%	N. Propylester of 3.5 Diiodo, 4 Pyridune N. Acetic Acid in oil
Umbradil Viscous B Perabrodil M Joduron B Diodone Visquese Methocel Wiodrast			Closely related mixtures of compounds of Diodrast type with Carboxy Methyl Cellulose
Dionosil Aqueous			N. Propylester of 3.5 Diiodo, 4 Pyridone N. Acetic Acid, mixed with Carboxy Methyl Cellulose
FOR CHOLOGRAPHY			
Ion			
2 Priodax	*Iodo Alphonic Acid* Bilitrast	51.4%	B (4 Hydroxy, 3.5 Diio Phenyl) Alpha Phenyl Protionic Acid
3 Telepaque	*Iodo Panoic Acid* Bilijodon Leo	66.7%	3 (3 Amino 2, 4, 6 Triiodo Phenyl) 2 Alkyl Propanoic Acid
3 Teridax		66.5%	
6 Cholografin (2x3)	Biligrafin Radioselectan	64.3%	Disodium N. N. Adipyl Bio (3 Amino 2, 4, 6 Triiodo) Benzoic Acid
FOR UROGRAPHY, VASOGRAPHY, ARTHROGRAPHY, ETC.			
1 Uroselectan	Iopax		5 Iodo, 2 Pyridone, N. Acetic Acid
1 Skiodan	*Methiodal Sodium* Abrodil Kontrast U	52.0%	Monoiodo Methane Sulfonic Acid Sodium
1 Hippuran			Sodium 0 Iodo Hippurate
2 Diodrast	*Iodo Pyracet* Diodone Uriodone Dijodon Umbradil Perabrodil Pyelosil Nosydrast Nosylan Pylumbril Neoskiodan Neotenebryl Perurdil Vasiodone	49.8%	3.5 Diiodo, 4 Pyridone N. Acetic Acid Diethanulamine
2 Neo-Iopax	*Sod Iodo Methamate* Iodoxyl Uropac Pyelectan Uroselectan B Urotrast Neo Iopax R Neo Iopax Sod Iodoxyl D-40 Urimbrin	51.5%	Disodium Salt, N. Methyl, 3.5 Diiodo, 4 Pyridone, 2.6 Dicarboxylic Acid
2 Hypaque	*Sod Diatrizoate*	59.8%	Composition not disclosed
3 Urokon-Sodium	*Sod Acetrizoate* Triurol	65.8%	No. 3 Acetylamino 2, 4, 6, Triiodo Benzoae

jected has been high enough (30-60 millilitres). There is no significant reaction associated with the injection. If the medium is injected into articulations, into the subarachnoid space, etc., it causes a rather marked foreign body reaction.

Thorotrast, however, has one very serious drawback: it is radioactive. Radioactive elements, if present in the tissues long enough, are known to cause the development of malignant processes. Thorium dioxide is not eliminated from the body. Several cases have been published where it is almost certain that malignancy has arisen as the result of thorium deposits. Animal experiments showed a high incidence.

The Thorotrast problem has another angle, because Thorotrast is an excellent medium for arteriography of the brain, causing less reaction than other media and resulting in better pictures. As the danger that a tumour will develop in a patient is really quite small, some investigators think that the advantages of better picture and less reaction outweigh the disadvantage of tumour risk. Other investigators think the opposite. It would seem that no one uses Thorotrast any longer for hepato-splenography.

For more than 15 years, media containing iodostearates have been tried for hepato-lienography. They were too toxic to become accepted. Recently some results with Angiopac, a colloidal suspension of ethyldiiodostearate have been published. The number of cases was quite small; there was no significant reaction from the injection. Only the spleen became visible.

The amount of iodine, selectively absorbed in the thyroid, never is sufficient to produce a contrast picture of that organ.

The progress in organography does not equal the progress in other fields. Yet, we hope that in this field, as well as in bronchography, the attempts at producing better media will soon be successful.

The X-ray diagnosis of arthritis is late and based upon indirect signs of soft tissue change and secondary involvement of juxta-articular bone.

Soft Tissue Radiography

Leon S. Wolfe, Meds '58

INTRODUCTION

It is almost thirty years since Hugo Laurell developed empirically a radiographic technique for the examination of the soft tissues. Laurell used a combination of long focal distance, low tube voltage and high definition intensifying screen to minimize focal blur, enhance contrast and reduce screen blur. Since these pioneering experiments of Laurell, a considerable number of papers have appeared on the technique and its value in the diagnosis of certain pathological processes. However, text books have given scant attention to the subject, and most authors indicate that the special value of the technique has not been sufficiently appreciated or practised.

Soft tissue radiography can be defined as the technique for the visualization of the soft tissues without the aid of contrast agents. Because the differences in X-ray absorption of the soft tissues is small it is necessary to pay greater attention to the procedure of making and viewing the radiographs. Sands (1955) stressed the importance of examining the soft tissues in plain radiographs. Often many important signs in these tissues are unnoticed or undervalued. The advantages of the technique are, first, it is simple, requiring no special preparation; second, it does not cause the patient any discomfort, and third, serial studies can be conducted easily. The technique may also be used in conjunction with insufflation techniques and injection of contrast media.

Theory

All roentgenograms are shadow graphs. The law of transmission of Roentgen rays through matter is a special form of Lambert's law of optics and can be expressed mathematically as follows:

$$I = I_0 e^{-ux}$$

Where I is the intensity of the transmitted radiation, I_0 the intensity of the incident radiation, u is the absorption coefficient, and x is the object thickness. The absorption coefficient of any tissue is a function of the mean atomic number of the tissue, its density, its thickness and the wave length of the radiation employed (Bragg-Pierce equation). For a tissue or object to cast a distinct image on a film and to be distinguishable from the background it is necessary that there be at least a two per cent difference between the intensity of radiation striking the film at the tissue or object site and the immediately surrounding areas. If the kilovoltage applied is adjusted so that eighty to eighty-five per cent of the radiation is absorbed by the tissue a distinct image of it will result.

The following table lists some of the tissues and organs with their densities and absorption coefficients (from Barnes & McLachlan, and Lingley & Elliott).

Tissue	*S.G.*	*Photo-absorption coeff. (lambda cubed)*
Bone-cortex	1.9	13.24 3
Hair	1.3	2.89 ....
Placenta	1.06	2.75 ....
Nerve	1.03	3.12 ....
Cartilage	1.11	2.70 ....
Thyroid	1.06	2.70 ....
Transudate	1.008	2.72 ....
Exudate	1.02	2.69 ....
Pus	1.06	2.67 ....
Muscle, blood, Liver, Spleen, Kidney	1.05-1.06	2.61-2.62 ....
Water	1.0	2.51 ....
Tendon	1.1	2.37 ....
Adipose tissue	0.92	1.37 ....

The kilovoltage used determines the wavelength of the radiation and consequently the degree of penetration. At low kilovoltages the X-rays are less penetrating and produce less secondary radiation fog but the radiographs show a short scale contrast with less fine detail. When it is desired to record large numbers of tissue densities (long scale contrast) higher kilovoltages are required. Fuchs (1943) claimed that with an optimum kilovoltage technique it was possible to obtain a fully exposed image with detail through the whole range from bone to flesh, with long scale contrast and with minimum secondary fogging.

Technique

The basic principle of the technique as outlined by Carty is the use of the lowest possible voltage which will penetrate the tissues being investigated and at the same time secure adequate contrast. Usually this is achieved by making the milliampere-time factor greater than that used for bone work and the kilovoltage 15-20 KV less. For routine examination of the soft tissues the usual technical adjustments are: *Kilovoltage, 40-60 KV; Anode current, 100-150 ma; Exposure time, 0.5-1.0 sec.; Target to film distance, 90-100 cm.* Invariably used are tubes with a small focal spot, intensifying screens to cut down exposure time and a Potter-Bucky diaphragm or other scatter eliminating device. The type of film chosen and the method of development are also important.

It is to be expected that each radiologist would develop his own technique because of the complexity of the interrelationships involved in the production of sharpness, contrast and harmony in an X-ray image. Allen and Calder have criticized the use of low kilovoltage methods which produce unnecessary contrast and stated that no distinction should be made between plain and soft tissue radiography. Contrast and definition of the soft tissues using high kilovoltages could be achieved by using an appropriate filter. Lewis emphasized the importance of studying the soft tissues and bones on the same film which could be done if the film was not made too dark and was studied with good illumination. A clearly marked skin outline is the most reliable criterion for a satisfactory film of the soft tissues.

Tissue Appearance

Soft tissue structures can be divided into two groups:

1. those with densities close to water, e.g. fibrous tissue, cartilage, muscle, blood and lymph
2. those with densities similar to fat, e.g. soft tissue and perirenal fat

Soft tissue radiographs of the extremities show five layers:

1. the skin outline
2. the translucent subcutaneous fatty layer with fibrous tissue septa giving it a reticulated appearance
3. line of subcutaneous fascia
4. muscle fascia layer
5. muscle tissue.

The individual muscles may sometimes be identified by differences in thickness and the direction of the intermuscular fibrous and fatty septa. Arteries and veins are visible only when contrast is offered by the surrounding fat, consequently superficial vessels are completely shown and the deep vessels only partially.

Four zones are visible in the supine-oblique films of the breast:

1. skin
2. translucent premammary subcutaneous tissue
3. denser breast tissue with characteristic striations produced by the fibrous strands and lactiferous ducts converging towards the nipple

4. retroglandular fatty tissue.
Tumour masses generally cast denser shadows than the breast tissue and alter the normal striations.

In Hay's extensive radiographic study of the neck, it is pointed out that the width of the retropharyngeal and retrotracheal soft tissue regions is useful in the diagnosis of phlegmon and tumours in this region. Similarly in chest films the width of the extrapleural and subcostal connective tissues is sometimes of value in the diagnosis of thoracic tumours, abscesses and empyemas. Important soft tissue landmarks in the abdominal radiograph are the outlines of the kidneys, bladder, spleen, lower margin of the liver and the psoas muscle.

In lateral films of the abdomen taken towards the end of pregnancy it is possible to distinguish maternal skin, abdominal muscles, uterine wall, foetal subcutaneous fat, and deeper foetal structures. The placental shadow represents the placenta plus the uterine wall and amniotic fluid.

Clinical Value

Many pathological processes influence the water and fat content of the soft tissues. Much information can be drawn from a study of the boundary zones of the soft tissues if the normal configuration and distribution of fat in the subcutaneous and deeper regions is fully understood. Changes in the relative distribution of fatty and non-fatty tissue can be recognized and the presence of pathological changes in many cases can be deduced. Soft tissue technique is of particular value in the examination of the soft tissues around the ankle, knee and elbow, the breast and placenta. However, the more recent techniques of placentography determines placental position better.

A summary follows of the more common conditions in which soft tissue radiography is of diagnostic value.

1. Changes in the periarticular soft tissues, e.g. synovitis, bursitis, tensynovitis, arthritis with effusion, scurvy, aneurysm, haemorrhage, cysts, abscesses, trauma, earliest sign of calcification.

   Distension of the joint capsule, irrespective of origin, displaces the extracapsular fat.

2. Changes in the subcutaneous layer: oedema, ascites fibrosis, cellulitis.
   In acute thrombosis of the lower limbs, the associated oedema produces a thickening of the skin line, an increase in the density of the muscle shadow and blurring of the muscle-subcutaneous fat border. Similar changes are seen in fractures, haematomas, cellulitis, osteomyelitis.

3. Changes in blood vessels:

   phlebitis, varicosities, haemangiomata.

4. Early atrophy of muscles and replacement by fatty tissue—anterior poliomyelitis, myasthenia gravis, disuse.

5. Lipomas and Liposarcomas.

6. Osteomyelitis:

   Baylin and Glen describe significant soft tissue changes which are visible well before bone changes can be seen.

7. Breast Tumours:

   Radiography adds little to what can be learned by a careful physical examination.

8. Placenta Praevia:

   Reid (1949) and Stevenson (1949) have shown that if the placental shadow is in the lower central or dorsal uterine segments or if it is not visualized at all, there is reason to suspect placenta praevia or low implantation and further diagnostic procedures should be carried out. The localization of the placenta is difficult in twin pregnancies and when there is hydramnios.

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Abstracts

INTRA-ARTERIAL ANTIBIOTICS AS AN ADJUNCT TO THE TREATMENT OF MALIGNANT TUMOURS WITH RADIATION AND CHEMOTHERAPY

J. W. Grossman et al,

Antibiotics Annual, 1954-1956

Intra-arterial chlortetracycline and tetracycline have been used as an adjunct in the treatment of malignant tumours which, by virtue of their lesion, have a considerable degree of infection associated with them. Infection is especially prominent when these tumours are moderately or far advanced. It is emphasized that radiation is still the most important factor in therapy. Methyl-bis-amine, nitrogen mustard, was used because of its destructive effect on malignant tissue, particularly when injected into the regional artery from which the tumour is most likely to draw its blood supply. An intra-arterial antibiotic was used to control infection and thereby prepare a tumour stroma most responsive to radiation and chemotherapy. There is also some evidence to support the theory that chlortetracycline may have a cytotoxic effect when employed in high doseage. The combined method of therapy should ideally be limited to suitable untreated cases, or cases which have not received a maximum of radiation and in which a favourable stromal response can be anticipated.

Combined therapy has been employed in moderately advanced and far advanced carcinomas of the oral cavity, maxillary antrum, nasopharynx, and cervix uteri. Treatment schedule:

1. Intra-arterial antibiotic, one gram per day by intra-arterial drip for 15 days.
2. Nitrogen mustard, 0.4 mgm per kilogram per day given in 3-5 equal doses beginning on the seventh day.
3. Radiation (X-ray, Cobalt 60, or radium), as indicated, following the intra-arterial phase of therapy.

Some of the problems and complications of this method of treatment are discussed. This form of therapy has been most gratifying in carcinoma of the head and neck, especially in carcinoma of the nasopharynx. Full assessment of combined therapy awaits long term studies.

—Douglas D. McGregor, Meds '56.

PLANIGRAPHY (BODY SECTION RADIOGRAPHY) IN DETECTING TUBERCULOUS PULMONARY CAVITATION

Edward A. Favis, M.D., F.C.C.P.,

Diseases of the Chest,

Vol. 27, No. 6, June 1955

The study involved 271 planigrams taken over a 5-year period (1948-1953). Each planigram was reviewed with special emphasis on detecting cavitation.

Planigrams were taken when one or more of the following conditions were present:

1. Suspicious areas seen in conventional films.
2. "Clear-cut" cavitation seen conventionally, but knowledge desired re depth and location.

3. Chest surgery contemplated in contralateral lung.
4. Persistent positive sputum or haemoptysis, in spite of negative conventional films.
5. Routine in discharge of patient with history of previous cavitation.
6. Re-expansion of collapsed lung being contemplated.
7. Choice of pneumoperitoneum, pneumothorax, resection, or thoracoplasty.
8. Conventional films revealed suspicious honey-combing or bronchiectatic cavitation.

Planigrams were taken in the recumbent position and 4-12 centimeter cuts inclusive were the routine. In all instances data was collected on X-ray findings in conventional films (P-A, Bucky, or apical-lordotic views) before planigrams were taken. These were usually taken on the same day.

Of the 271 planigrams, 10.7% conclusively showed cavitation when none was apparent in conventional views. Another 8.8% also showed definite cavitation while only suspicious areas appeared on the conventional films. It was believed that this total of 19.5% was sufficiently great to warrant the more liberal use of planigraphy in discovering tuberculous cavitation.

It was pointed out that planigraphy should not be considered as the "last word" in the detection of cavities.

—Gordon P. Scratch, Meds '58

A STUDY OF 100 PATIENTS TREATED WITH RADIOACTIVE PHOSPORUS

J. H. Lawrence, M.D., B.V.A., Low-Beer, M.D., and J. W. J. Carpenter, M.D.

(Reprint with recent additions)

J.A.M.A., June 1949, Vol. 140

The authors discuss their experiences with the use of P^{32} in a series of 100 cases over 12 years.

The doseage estimation is based upon results with total body irradiation and the calculation that one microcurie of P^{32} per grain of tissue will give about 40 r. of irradiation in 24 hours. Fifty-eight per cent of the cases had roentgen therapy either before or after P^{32}.

Treatment:

Enough P^{32} was given to produce symptomatic relief. A "good" result included an improved R.B.C. count and decrease in the size of the spleen and lymph nodes. No attempt was made to bring W.B.C. count to normal (with normal differential for fear of overdepression of bone marrow. Average patient received 1-2 millicuries per week for 4-8 weeks, repeated when indicated by return of symptoms.

Comment:

Generally the series showed a small increase in average life expectancy as compared with other series in which roentgen irradiation alone was used. Thirty-five per cent survived five years or more after onset and 13% had survived 8 years or more at time of counting. Other observers report average duration of 3.4 years regardless of treatment. Success depends upon the greater sensitivity of leukemic cells. Limitations of the therapy are the adverse effects on normal cells, and the decrease in the ratio of sensitivity between normal and malignant cells.

Control seems possible in a good percentage of cases and the ease with which it is accomplished, combined with the lack of radiation sickness, make the use of P^{32} advantageous.

—Barry Pless, Meds '58

List of Recent Accessions

The Library of the Medical School contains about 50,000 volumes, all fully catalogued, and is regarded as one of the best working collections of its kind in Canada. It is particularly rich in complete files of the more important medical journals. The books are on open shelves and students have access to all books and current journals.

HUMAN ANATOMY

Boyden, E. A.: Segmental anatomy of the lungs.

Altschul, Rudolf: Endothelium, its development, morphology, function and pathology.

Ramon y Cajal, Santiago: Histologie du systeme nerveux de l'homme & des vertebres.

PHYSIOLOGY

Dukes, H. H.: The physiology of domestic animals. 7th ed.

Elkinton, J. R.: The body fluids; basic physiology and practical therapeutics.

Granit, R.: Receptors and sensory perception.

Gaddum, J. H.: Polypeptides which stimulate plain muscle.

MEDICINE (GENERAL)

Mitchell, R. B.: Medicine in Manitoba.

Gordon, S.: The scalpel, the sword, the story of Dr. Norman Bethune.

Moody, J. P.: Arctic doctor.

PUBLIC ASPECTS OF MEDICINE

Hill, A. B.: Principles of medical statistics. 6th ed.

Commission on Financing of Hospital Care. Financing hospital care in the United States.

Irvine, K. N.: B.C.G. and vole vaccination.

Frankel, M.: Morbidity in the municipal hospitals of the city of New York.

Smith, S. A.: Forensic medicine. 10th ed.

Thienes, C. H.: Clinical toxicology. 3rd ed.

PATHOLOGY

A Textbook of clinical pathology, edited by S. E. Miller. 5th ed.

Nabarro, J. D. N.: Biochemical investigations in diagnosis and treatment.

Journal of chronic diseases.

INTERNAL MEDICINE

Tidy, Sir H. L.: A synopsis of medicine. 10th ed.

Top, F. H.: Communicable diseases. 3rd ed.

Moss, E. S.: Atlas of medical mycology.

World Health Organization. Poliomyelitis.

Kenny, E.: My battle and victory.

Cowdry, E. V.: Cancer cells.

Phillips, A. J.: Mortality trends in Canada for various sites of cancer.

Brain, W. R.: Recent advances in neurology and neuropsychiatry. 6th ed.

Murphy, J. P.: Cerebrovascular disease.

Freud, S.: On aphasia.

Alexander, H. L.: Reactions with drug therapy.

White, P. D.: Clues in the diagnosis and treatment of heart disease.

SURGERY

McVay, C. B.: Hernia.

Moseley, H. F.: Textbook of surgery. 2nd ed.

Partipilo, A. V.: Surgical technique and principles of operative surgery. 5th ed.

Tarrow, A. B.: Basic sciences in anaesthesiology. 2nd ed.

Ferguson, L. K.: Surgery of the ambulatory patient. 3rd ed.

Welch, C. E.: Surgery of the stomach and duodenum.

Bateman, J. E.: The shoulder and environs.

Bailey, C. P.: Surgery of the heart.

Epstein, B. S.: The spine, a radiological text and atlas.

OPHTHALMOLOGY

Sorsby, A.: Modern trends in ophthalmology. 3rd series.

Hughes, W. L.: Reconstructive surgery of the eyelids. 2nd ed.

GYNECOLOGY & OBSTETRICS

Bonney, V.: A textbook on gynaecological surgery. 6th ed.

Hunt, E.: Diseases affecting the vulva. 4th ed.

Beck, A. C.: Obstetrical practice. 6th ed.

Synopsis

Wally Stavraky, Meds '58

TThe following is a synopsis of radiological articles which have appeared in the past issues of the U.W.O. Medical Journal, summarized here for the sake of completeness.

G.I. ROENTGENOLOGY

B. J. Shapiro, M.D., C.M.
U.W.O. Medical Journal, November '53

Basic Essentials:

Early attempts with Bismuth subnitrate and bismuth subcarbonate were not so successful. These have been replaced with barium sulphate. Both fluoroscopy and films are the accepted method.

Esophagus:

Mediastinal tumours or thyroid enlargements will displace the esophagus from its normal indentation to the right. A Valsalva manoeuvre will demonstrate varices or a hiatus hernia.

Stomach:

Malignancy may be detected by irregularity or thickening of mucosa, a peristaltic skip area, or a filling defect.

An ulcer may show radiating folds of mucosa, a peristaltic skip area, but most commonly as a crater distended with barium sulphate.

Duodenum:

Deformity of the duodenal cap may reveal a duodenal ulcer and a crater may be demonstrated.

Small Intestine:

Fluroscopy will show abnormalities in normal intestinal movements as well as defects in the mucosal surfaces. Normally, no gas should be seen in the small bowel, and if present, usually denotes obstruction.

Colon:

The colon is examined by means of an opaque enema administered during fluoroscopy, in order to demonstrate any inequalities in filling.

Following evacuation, a residual coat is left on the mucosa, allowing examination of mucosal folds. Gas may be injected to provide double contrast.

DIAGNOSTIC VALUE OF PNEUMOGRAPHY OF THE KNEE JOINT

Paul P. Hauch, M.D.
U.W.O. Medical Journal, March '52

Pneumography permits a wider investigation of the knee joint than other methods. A non-radio opaque substance, such as air or gas, will not block out pathology and remains in the joint for longer periods without being absorbed. Statistics show that of all X-rays of extremities in all Canadian D.V.A. hospitals, over a period of twelve months, the knee joint constituted the greater number (6,838) with the shoulder joint second (4,575). Of these 6,838 only 130 had pneumographs. Of 400 cases examined with pneumograms (by Dr. Hauch), 136 of these came to operations, and it is noted that the accuracy of diagnosis increased from 48% using clinical methods to 88% with pneumograms.

Some of the conditions which may be detected are:

1—tear or fracture of meniscus,

2—abnormal regeneration of fibrous tissue after meniscectomy,

3—tear of collateral ligaments,

4—tear and atrophy of arcuate ligaments,

5—calcification in menisci,

6—capsular tears.

Dr. Hauch advocates that pneumography should become an integral part of the examination of knee injuries, particularly in cases which have remained undiagnosed for a period of time in cases whose signs and symptoms are indefinite.

CLINICAL ANGIOCARDIOGRAPHY

James G. Frid, M.D.

U.W.O. Medical Journal, November '50

Angiocardiography is the visualization of the cardiac chambers, the aorta, and the pulmonary artery by injection of a radio opaque substance. Methods are of two major groups:

1—visualization of only parts of the heart and major blood vessels,

2—study of the complete circuit of the contrast media through the heart and blood vessels.

Preparation of the patient is the same in both instances. All age groups may be examined, however, in order to insure cooperation. Children and infants may be sedated or placed under general anaesthetic. The patient is fluroscoped to determine the optimum position for best visualization. The erect position is considered to be the best, since there is least distortion of the heart. The right or left antecubital vein is cannulated and a small dose of the medium, usually diodrast, is injected to determine sensitivity. Difficulties arise in supplying film fast enough to photograph the passage of the material.

In the first type of examination previously mentioned, circulation time to the particular part must be pre-determined and the exposure made at that time. In the second type of examination, when the whole circuit must be examined, there are three methods available:

1—rapid movements of cassettes (film-container) by moving holder,

2—rapid still photography of moving screen,

3—movie photography.

Angiocardiography may be used in the following clinical conditions:

1—differential diagnosis of acute aneurysm and mediastinal tumour,

2—obstruction of superior vena cava,

3—congenital heart disease,

- (a) abnormality of a large vessel or cardiac chamber outlet,
- (b) pulmonary stenosis,
- (c) patent ductus arteriosus,
- (d) left to right intra cardiac shunt,

4—vascular pattern in the lungs.