PRELIMINARY REPORT ON THE USE OF CONTRAST MEDIA IN ORBITAL RADIOGRAPHY

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The use of contrast media in the orbit dates from 1927, when Staunig and Herrenschwand injected air into the episcleral space, and since that time various media have been used. The ideal medium should provide good contrast in small quantities, be non-irritant, and have suitable qualities of permeation and absorption. The following media will be considered:

1. Air or other gas,
2. Oily media,
3. Water-soluble media, of which it is known that the least irritant is diodone.

1. Air has the disadvantages of providing poor contrast when used in small quantity, and since relatively large volumes have to be employed (6 to 15 ml.) it causes exophthalmos, discomfort to the patient, and, at times, surgical emphysema of the lids. The rate of absorption is slow (5 to 7 days, Friedman, 1947), but de Abreu (1952) claims that it can be reaspirated. A more rapid reabsorption would be obtained by the use of oxygen (Scheie and Hodes, 1946). A gaseous medium has the theoretical advantage that it could be used to localize a foreign body of poor opacity. The literature (Gasteiger and Grauer, 1929; Spackman, 1932; Last, 1938, Oribe, 1937; Peter and Rosen, 1945; Hughes and Cole, 1946; Friedman, 1947; Puglisi-Duranti, 1947; de Abreu, 1952) appears to record no serious sequelae.

2. Oily solutions (Speciale-Piccichè, 1927; Sandera, 1930; Farberow and Medvedev, 1935) have the advantages of remaining localized and providing good contrast, but they do not permeate evenly and tend to form pools in the tissues. The resultant radiographs are unreliable and difficult to interpret. Absorption is very slow and the medium acts as a long-term irritant.

3. Of the water-soluble media, general radiological experience has shown diodone to be the most satisfactory, in that it provides good contrast with the minimum of tissue irritation. The compound permeates readily through the tissues and absorption is so rapid that dispersal and absorption of the medium is so advanced 10 minutes after injection that no useful radiographs can be taken. After one hour there is no radiological evidence of residual medium. Compounds of this type have been used by Katz and Ledoux (1935) to determine the length of the eye and by Pettinati (1953) to localize orbital foreign bodies. This medium has also been used by Manchester (1953).

The threefold aim of the present investigation has been to discover:

(1) Radiographic appearances after injection of tissue planes in the normal orbit.

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Tolerance of orbital tissues to diodone.
Possibility of applying these normals to the problems presented by the localization of foreign bodies and tumours.

We desire to present a technique using the simplest of apparatus and, with an x-ray machine of low capacity, such as the standard mobile unit, we can obtain consistent radiographs of reasonable quality.

Method

Injections of contrast medium were made separately into the various tissue spaces in the orbit in an attempt to establish the normal appearance. Cadavers were used, most of which had had the brain removed in the course of normal autopsy. In these cases a mobile unit was employed and the exposure was 75 KV. 30 mA. at 30 in., 1.5 sec. in the lateral projection and 1.25 sec. in the postero-anterior projection in decerebrate cases, increasing to 4 to 5 sec. with the brain in situ. Grid cassettes or stationary grids were used. Coned views did improve the definition, but they were not used routinely. The projections employed were the standard lateral, the occipito-mental, and that for the optic foramen. Diodone 35 per cent. solution was the standard medium for the post-mortem studies.

In the cadaver the episcleral space was difficult to fill completely with one injection, and amounts greater than 1.5 to 2 ml. tended to burst through Tenon's capsule into the muscle cone. Previous authorities using air have employed larger injections (6 to 15 ml.) and must in our view have filled the muscle cone or "central surgical space" (Duke-Elder, 1952, 1954). It was not always easy to penetrate into the episcleral space and the most consistent results were obtained by inserting the needle some 8 mm. from the limbus through the external rectus muscle, which was lifted away from the globe by forceps. The point of the needle was kept in close contact with the eye until the required area was reached. A curved needle was not found to be necessary. Failure to reach the space results in an atypical muscle cone picture; but after an adequate injection the lateral view shows a crescentic opacity whose posterior margin is clear and well defined. The anterior margin of the crescent shades off because part of the space is viewed not at a tangent but more or less at right angles (Fig. 1).

In the postero-anterior
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The view, the opacity forms all or part of a circle, according to whether complete filling is obtained or not.

The muscle cone or central surgical space (Duke-Elder, 1952, 1954) was satisfactorily demonstrated by injecting 4 ml., which produced a constant and easily recognized pattern, the injection being given as for a block of the ciliary ganglion. In the postero-anterior view, the opacity resembles an irregular four-leafed clover, and we believe that the extra-ocular muscles lie in the indentations between the leaves and give rise to these appearances by resisting the expansion of the contents of the cone while the inter-muscular fascia balloons (Fig. 2).

In the lateral view, the term “muscle cone” describes the appearance adequately and the quantities used give a cone with slightly concave sides. Quantities greater than 4 ml. are liable to rupture into the outer surgical space (Fig. 3) and obliterate that small space usually found between the cone and the bony orbit.

Fig. 2.—Postero-anterior projection of inner surgical space. Some leakage to the outer surgical space is seen in the supero-medial quadrant.

Fig. 3.—Lateral projection of inner surgical space.
The peripheral surgical space (Duke-Elder, 1952, 1954) can usefully be filled only in quadrants, as more extensive filling would render interpretation of the radiographs impossible, the image of one quadrant confusing that of its neighbour. This space appears abnormally large as media injected into it readily compress the muscle cone (Fig. 4). No experience of this is available in the living patient.

To complete the radiographic picture of the orbit the position of the eye can be demonstrated by replacing the vitreous with diodone (Fig. 5).

In order to assess the distortion caused by space-occupying lesions of known size, warm cocoa-butter, which rapidly solidifies in the cadaver was injected. By dissection it was confirmed that it assumed a relatively compact shape. Diodone solution was then injected into the fascial space occupied by the "tumour" or into the adjacent one. Under these artificial conditions, the best pictures were obtained by having the two materials in adjacent compartments. Significant distortion has been noted with "tumours" as small in volume as 3 ml.

In Fig. 6 (opposite) the "tumour" has been made more evident by mixing barium powder with the wax, and it is shown to displace and compress the cone.

If the mass lies inside the cone, then an injection into this space shows it to be ballooned and of abnormal pattern (Fig. 7, overleaf).

General radiographic experience has shown that diodone is the least toxic of the water-
soluble media. Assuming that the weaker the concentration the less the irritant effect on the tissues, we have attempted, by cadaver studies, to find the minimum concentration with which satisfactory radiographs can be obtained. A 17 per cent. solution appears to be the weakest useful concentration and this strength is obtained by mixing 35 per cent. diodone and 4 per cent. Novocain in equal quantities. If the route of injection lay through the conjunctiva, this was anaesthetized with gutt. cocaine 5 per cent. This concentration of diodone was first tested by injection into four patients who were awaiting enucleation. There was no complaint of pain at the time of injection, but after one hour, a period consistent with the duration of action of the local anaesthetic, they suffered from a dull pain behind the eye lasting about 5 or 6 hours, which was readily controlled by mild analgesics. At operation, the tissues appeared normal and orbital implants were inserted and worked satisfactorily. From this evidence it was deemed safe to use the method in cases where a functioning eye was to be retained. In six cases where the medium has been employed, there has been no evidence of impaired vision or ocular motility following the injection. In one case where two injections, separated by an interval of 1 hour, were employed, the orbital tissues were found to be slightly congested when exposed at operation 24 hours later. Water-soluble contrast media injected into the episcleral space have been used by Katz and Ledoux (1935), Pettinati (1953), and others, to determine whether a foreign body is inside or outside the globe. This method is, obviously, of greatest value when the state of the ocular media is such as to preclude accurate ophthalmoscopic examination. In our patient, routine x-ray examination indicated a foreign body near the posterior pole; 2 ml. 17 per cent. solution of diodone in 2 per cent. Novocain was injected into what we thought was Tenon's space, but the films showed a characteristic muscle cone picture; after 1 hour, a further 2 ml. was injected, and satisfactory radiographs were obtained (Figs 7 and 7a, overleaf).

In a second patient, the medium entered the lateral part of the inner surgical space instead of the episcleral space. Precise localization was, therefore, not possible. On stereoscopy, the foreign body was shown to lie posteriorly and within the eyeball. As the foreign body had been present for 18 months, it was possible that inflammatory changes had obliterated Tenon's space. Such adhesions have been postulated by Pettinati (1953). For this method of localization

Fig. 6.—Opacified "tumour" displacing inner surgical space downward.
Fig. 7.—Lateral view after injection of 2 ml. diodone into Tenon's capsule.

Fig. 7(a).—Optic foramen projection of 2 ml. diodone injected into Tenon's capsule.
to be accurate, we require not only occipito-mental and lateral projections but additional views tangential to the globe at the point nearest to the foreign body.

We have confirmed the accuracy of this method in the cadaver by inserting foreign bodies in varying and known relationships to the posterior pole of the eye and confirming their position by the method just described.

Stereoscopic films have been found to be of considerable value. They give a clear impression of the relationship of the foreign body to the opaque medium and hence to the posterior pole of the eye. This should be of greatest value when tangential views would be complicated by dense bony shadows, e.g., petrous bone. Such radiographs have readily been obtained with a mobile x-ray machine.

Material

Four cases of orbital space-occupying lesions have been investigated:

Case 1, a female aged 42 years, had a chondro-sarcoma originating in the right maxillary antrum and investigation was undertaken to determine the degree of orbital invasion. Plain radiographs showed a mass filling the right maxillary antrum, and the lower margin of the orbit especially in its medial portion had been destroyed. The medial and inferior wall of the antrum also appeared to have been destroyed. Injection of medium into the inner surgical space demonstrated an upward displacement of the orbital contents. Since the muscle cone showed its characteristic shape despite displacement, no gross invasion of the orbital contents was probable and this was confirmed at operation.

Case 2, a male aged 51 years, had postural exophthalmos considered to be due to an orbital varix. Control films showed no abnormality of the bony orbit, 4 ml. 17 per cent. solution of diodone was injected into the inner surgical space and the resultant radiographs showed enlargement of the muscle cone shadow with a mottled appearance suggestive of filling defects within the cone. The appearance was similar to Fig. 8.

Fig. 8.—Ballooned inner surgical space caused by presence of artificial tumour.
Case 3, a boy aged 12 years, had had a plexiform neurofibroma of the right orbit for 5 years and the diagnosis was confirmed by examination of tissue removed at operation 2 years ago. Plain radiographs showed enlargement of the right orbit and depression of the floor and the fronto-nasal process. The sphenoidal fissure and the optic foramen were enlarged. An injection of diodone into the inner surgical space gave radiographs showing a filling defect of the muscle cone with the lateral projection. There was thickening of the outer surgical space. A central filling defect showed in the optic foramen projection suggesting a tumour in or about the optic nerve (Fig. 9).

Fig. 9.—Enlargement of orbit and outer surgical space with central filling defect.

Case 4, a male age 55 years, had had for the last 4 months a paresis of the right superior rectus and the right external rectus muscles and slight exophthalmos, there being only 2 mm. difference between the two eyes. Routine investigation and plain radiographs showed no abnormality. An injection of diodone into the muscle cone was made and the resulting radiographs showed abnormal patterns in both the postero-anterior and lateral projections. In the postero-anterior projection the upper margin of the diodone appeared to be displaced downwards and to be somewhat irregular, though retaining fundamentally the pattern which we have described. In the lateral projection the upper margin of the diodone shadow was flattened and displaced downwards with consequent widening of the outer surgical space (Fig. 10, opposite). The neurosurgeon is now unwilling to perform a transfrontal exploration as it is felt that the exophthalmos is minimal and not rapidly progressive and the operation will leave the patient in a worse clinical state.

Results

We have failed to find any previous radiological demonstration with contrast media of the normal fascial planes of the orbit. We have endeavoured to show that consistent radiographs are obtained with the technique described and that any delay between the injection and radiographic exposure...
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Fig. 10.—Downward displacement of inner surgical space.

will result in loss of definition due to rapid permeation and absorption. The interval available for useful exposure would appear to be about 10 minutes and this is sufficient for the three standard views. With the skull radiography unit, stereoscopic views in the three projections can be taken well within the crucial time. We feel that the standard appearance might well have escaped our notice had studies not been made in the cadaver.

It would appear from this and other work that 17 per cent. diodone solution can be injected into the tissue spaces of the orbit with a minimum of adverse effect. In our experience, the method has been without complications. There is a slight risk of a reaction to the iodine content of the medium, but this is very rare and can be prevented by routine sensitivity tests.

This technique would appear to have at least two clinical applications:

(1) Localization of foreign bodies.
(2) Investigation of orbital space-occupying lesions.

The use of opaque media in the localization of foreign bodies is not new and our findings are in accord with previous work. In our view, the method is safe, simple, and reliable, but is indicated only in selected cases: where the foreign body cannot be seen with the ophthalmoscope and is believed to be in close proximity to the sclera, especially near the posterior pole of the eye. This method has the great advantage of being accurate in all cases and not dependent on the concept of a standard size of eye, which we know to be fallacious. The only contraindication to this method would be a large wound in the eye, when pressure on the posterior pole would cause loss of vitreous or other ocular contents.
The applicability of this technique to the investigation of space-occupying lesions has been tested clinically. We consider the method to be worthy of further trial and intend to use it as opportunity arises. It has been presented in a provisional form, as suitable cases are uncommon and adequate trial will extend over a long period. With this method, we hope to be able to confirm the existence of a mass and to localize it by showing deformation and invasion of tissue spaces. We have had too little clinical material to lay down precise criteria for the site of the injection and the abnormalities in the radiological pictures which one would expect to be produced by different pathological conditions. We consider that the most generally valuable results are obtained by injecting the inner surgical space. On the other hand, it would appear that the best radiographs are secured by filling the tissue space adjacent to the tumour, so that if the mass is deemed to occupy the central surgical space an alternative approach might be advisable, for example, injection of the episcleral space. This should show if the mass has become adherent to the globe. In general, deformity of tissue space patterns will be produced by simple pressure which will displace or distort, or by adhesion and invasion which will obliterate.

This technique is, perhaps, open to the criticism that the trauma associated with the injection might cause dissemination of malignant cells. Any retrobulbar injection is liable to cause a haematoma, which would be more likely if a vascular tumour were present but this does not usually cause any gross inconvenience to the patient except temporary disfigurement due to blood-staining of the lids.

Hyalase was added to the mixture in one case but did not facilitate filling of the episcleral space and an increase in the rate of absorption is neither necessary nor desirable.

The technique as presented is simple and requires the minimum of apparatus. Where available, tomography would be a refinement which should resolve difficulties occasioned by overlying bone, but it might be difficult to accomplish in the time available after the injection.

In the localization of foreign bodies, image amplification may, in the future, facilitate the obtaining of tangential views by direct observation.

Summary

The various types of contrast media having been discussed, diodone is considered to be the medium of choice. A standard technique is proposed for injection of the various tissue spaces of the orbit. Relatively constant radiographs have been obtained in the cadaver and confirmed in vivo. We consider that deformation of these should be of value in localizing space-occupying lesions and foreign bodies in the orbit. This has been confirmed in a small series of cases and the method appears to be safe and worthy of further trial.
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