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FRACTURES OF THE SPHENOIDAL SINUS WITH CEREBROSPINAL RHINORRHOEA

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It is now generally accepted that cerebrospinal fluid (C.S.F.) rhinorrhoea following a head injury indicates a dural tear in relation to a fracture involving the paranasal sinuses, and that a fascial repair of the torn dura is required as an insurance against intracranial infection in the future. Most of the fractures involve the frontal or ethmoid sinuses.* In this paper we consider only the relatively uncommon group in which the rhinorrhoea was due to fracture of the sphenoidal sinus. Such fractures are not always detected by radiological examination, and a full exploration of this region involves special problems of exposure and accessibility. It seems that there are certain clinical characteristics which may lead to their detection pre-operatively.

Anatomy

The sphenoidal air sinuses lie in the body of the sphenoid bone and are usually asymmetrical and

FIG. 1.—The outline of the sphenoidal sinus (interrupted line) in relation to the base of the skull.

separated from one another by a bony septum. They vary considerably in size and may extend into a well-marked lateral recess in the great wing of the

sphenoid. Fig. 1, drawn from a necropsy specimen with the dura intact, shows that the sinus extends forward into the anterior fossa, and also laterally beneath the optic foramina. The sphenoid sinus may therefore be implicated by fractures running across the posterior part of the anterior fossa as well as by fractures of the middle fossa. The close relationship of the sinus to the optic nerves and chiasm, to the pituitary body, and laterally to the carotid arteries is apparent. And in front of the optic chiasm and the upper part of the subjacent pituitary body is the cisterna chiasmatica, which is continuous on each side with the arachnoid sheath of the optic nerves.

Incidence

In the years 1938-46, at the Radcliffe Infirmary, Oxford, and the Military Hospital for Head Injuries, Oxford, we have seen 84 patients with cerebrospinal rhinorrhoea following closed head injury. In 11 there was demonstrated at operation or necropsy a dural tear in relation to a fracture of the sphenoidal sinus. Six of these, however, must be excluded from the present examination because they also had other dural tears in relation to the frontal or ethmoidal sinuses, and it was therefore not possible to say with certainty which tear was responsible for the rhinorrhoea.

In the other five patients the dura was torn only over the sphenoidal sinus, and these cases are examined in closer detail. Three patients underwent a fascial repair and have remained well since, nearly four years after the operation. The other two patients died of pneumococcal meningitis, both in the days before penicillin therapy. One of these was admitted moribund and died within 24 hours of admission; the other developed meningitis on the day before operative repair was proposed, and he died nine days later.

The Fracture

The sphenoidal sinus may be fractured in several ways following head injury.

1. After a blow directed to the side of the head, the skull breaks in the coronal plane, either through the

*In exceptional circumstances the fracture involves the petrous bone and the C.S.F. passes into the nose by way of the middle ear and Eustachian tube (Cairns and Lewin, to be published).

coronal suture, which is splayed, or just behind the suture and anterior to the parietal eminences. The fracture runs down into each temporal fossa and then across the middle fossa to involve the wall of the sphenoidal sinus at the tuberculum sellae or in the anterior wall of the sella turcica (two cases).

2. A head-on blow produces a severe central frontal fracture with comminution of both walls of the frontal sinuses, from which fracture lines run backwards to involve the ethmoid and occasionally sphenoidal sinuses. In some of these cases there is a large central block fracture involving the whole paranasal sinus area of both sides (two cases).

3. The head-on blow may be taken lower down, so that the bony injury is predominantly facial, resulting in a central block fracture of the maxilla, and in some cases a fracture of the mandible as well. The overlying cribriform plate may be comminuted. This is a fracture which on routine radiography may seem to be entirely extracranial: the extent of the damage to the cribriform plate and sphenoidal sinus may not be fully appreciated unless special radiographic projections of the paranasal sinuses are taken through the orbit, as recommended by Davies (Calvert, 1942) and Johnson and Dutt (1947) (one case).

4. The above are the ways in which the fractures occurred in our series. In addition it is possible that there may be discrete fractures of the skull limited to the roof of the sphenoidal sinus, similar to those which have been seen on the roof of the ethmoidal cells at operation and necropsy (Johnson and Dutt, 1947; Cairns, 1949, Fig. 8).

The Dural Tear.—This may be extensive, but we have had to exclude from this series cases in which the gap

in the dura involved the ethmoidal as well as the sphenoidal roof. In the five cases in which the dural tear was limited to the sphenoidal sinus area, the tear was usually only a few millimetres wide and was situated over the tuberculum sellae or the anterior wall of the sella turcica. It probably resulted from splintering of the thin bone in this region.

The Cerebrospinal Fluid Rhinorrhoea

The outstanding feature of these sphenoidal cases is the nature of the rhinorrhoea. It is characteristically profuse. In these five patients it was so described, and that it should have been so recorded by different clinicians renders what is an essentially qualitative observation the more reliable. In all patients the rhinorrhoea, once begun, continued unabated until operation or death, in one case for six months.

The following case record gives a typical description of the rhinorrhoea.

Case 1.—This patient sustained a coronal fracture of the skull at the level of the coronal suture following a motor-cycle accident. C.S.F. rhinorrhoea was present from the time of injury, and a note made 15 days later reads: "This soldier continues to have profuse C.S.F. rhinorrhoea whenever he sits up and leans over. For the last few days it has been coming down the left nostril only, though hitherto it has sometimes been from the right and sometimes from the left nostril. When the patient is lying in the dorsal recumbent position he feels fluid passing down his nasopharynx and has to swallow from time to time. During the night, when he is asleep, it tends at times to get into his larynx and he is awakened with fits of coughing, sometimes severe. The patient was sat up this morning, and within a few moments watery fluid began to drip from the left nostril—about a drop every second or less. I collected 4 ml. for examination and then let him lie down. I think the drip would have continued indefinitely in the sitting position.

In one patient (Case 2) a profuse rhinorrhoea began one week after the injury, at the same time as pneumococcal meningitis. The meningitis was treated with intrathecal penicillin, but showed a marked tendency to relapse. The C.S.F. escaping from the nose contained a considerable amount of penicillin, and it is not unlikely that the two relapses of meningitis, which occurred at two and four weeks after the accident, were associated with inadequate concentrations of penicillin within the meninges owing to its continual escape with C.S.F. from the nose. We have seen a similar "leakage" of

FIG. 2.—Case 2. Radiograph taken 26 days after the accident, showing air in cisterna chiasmatica, anterior horn of lateral ventricle, and subdural space.

penicillin from the subarachnoid into the subdural space in an infant after head injury (Smith *et al.*, 1946, Case 8).

How common is such profuse rhinorrhoea? In our 79 cases of cerebrospinal fluid rhinorrhoea not due to sphenoidal sinus injury the rhinorrhoea was profuse in only four cases. These patients had large tears in relation to the frontal or ethmoidal sinus. The explanation of the high incidence of profuse rhinorrhoea in sphenoidal sinus tears must be anatomical and due to the fact that the dural tear establishes a communication between the cisterna chiasmatica and the nose. By contrast, the subarachnoid spaces over the frontal pole are small, so that profuse rhinorrhoea from tears further forward is correspondingly uncommon.

The time of onset of the rhinorrhoea after injury in these five patients was variable. It came on at once in two cases, but was delayed seven to ten days in two cases and nine weeks in the remaining case. Such variability is seen in all groups of traumatic rhinorrhoea. The onset of rhinorrhoea depends not only on the type of fracture but also on whether the dural tear is temporarily sealed by blood clot or brain tissue. For this reason rhinorrhoea after anterior fossa fractures may begin seven to ten days after injury, when the oedema of the surrounding brain tissue is subsiding, the pulped brain is liquefied, and the blood clot is undergoing organization. Other factors are necessary to explain the very delayed onset which is sometimes met with.

Aerocoele.—With such a ready access to the basal cisterns, air may enter the cranium and be seen on x-ray examination of the skull. In one case, for the first month after injury air was seen in the subdural space, ventricle, and cisterna chiasmatica, but not in the brain. Fig. 2 shows the air in this cistern, and such localization should suggest that the dural tear is in relation to the sphenoidal sinus.

Other Signs

Preservation of Smell.—Theoretically, if the bony damage is confined to the sphenoidal sinus region and does not extend into the ethmoids, the sense of smell should be preserved, and this was in fact so in two of the four patients whom we have had under investigation. Nevertheless, no absolute reliance can be placed on this observation, for not only may severe frontal sinus fractures occur without disturbance of smell, but in apparently isolated sphenoidal cases the olfactory filaments may be damaged extracranially, particularly when the brunt of the injury is borne facially.

Injury to Neighbouring Structures.—Clinical evidence of damage to the hypothalamus and pituitary gland (diabetes insipidus, inverted sleep rhythm, glycosuria, or obesity), to the optic chiasm, or to the carotid artery was present in two of the five cases. One patient had

diabetes insipidus; the other had a visual field defect due to damage to the optic chiasm and also a carotid aneurysm. The accompanying Table, compiled from our 200 cases of paranasal sinus fracture following closed head injury, shows that, though these neighbourhood signs are commoner in the presence of a sphenoid fracture, they are by no means rare with fractures involving the other paranasal sinuses.

Risk of Intracranial Infection

Three of our five patients developed meningitis, in all instances pneumococcal, two within a week of injury and the other eight months later. Two of these cases occurred before penicillin was available, and were fatal. The third patient was treated with penicillin, recovered from the meningitis, and subsequently underwent a successful fascial repair of his dura (Case 2).

In our total series of 84 cases of cerebrospinal rhinorrhoea the incidence of intracranial infection was 19%. Thus it would seem that the risk of meningitis is greater with sphenoidal sinus fractures than with fractures of the other paranasal sinuses.

The close proximity of the basal cisterns renders patients with sphenoidal sinus fracture particularly liable to meningitis, and dural repair should be done as soon as possible. Another reason for early operation is that if meningitis supervenes and the rhinorrhoea is profuse, it may be difficult to establish an adequate concentration of penicillin in the C.S.F. by intrathecal injections.

Diagnosis and Operative Treatment

The difficulties of obtaining a satisfactory repair of a dural tear over the sphenoidal sinus may be considerable, but they can be overcome if beforehand the possibility that the tear is over the sphenoidal sinus has been suspected and the operation has been planned to provide a good exposure of the sella turcica region. Radiographic demonstration of a fracture of the sphenoidal sinus may be extremely difficult, but this lesion should be suspected when, in the absence of radiological evidence of a gross fracture of the posterior wall of the frontal sinus or of the roof of the ethmoid, there is profuse rhinorrhoea. Additional evidence in favour of the sphenoidal location of the trauma is the presence of air in the cisterna chiasmatica, as shown by radiographs.

Faced with the possibility that the C.S.F. is escaping through the sphenoidal sinus region, the surgeon must be prepared to make a full bifrontal exposure and, if need be, to divide olfactory tracts which are functioning normally.

The intradural approach for dural repair, as used by Julian Taylor (Eden, 1942), is the only way by which these sphenoidal tears can be fully demonstrated. A bifrontal flap is turned. The dura is then opened along the anterior limb of the flap on each side of the sagittal sinus, and the inner surface of the dura covering the frontal and ethmoid sinuses is inspected for tears, first on one side and then on the other. If no gross tear, sufficient to account for the profuse rhinorrhoea, is found, the anterior fossa must be widely exposed. The anterior end of the sagittal sinus, the falx, and one or both olfactory tracts must be divided. It is then possible to retract both frontal lobes freely and thus to obtain a good view of the optic groove and sella turcica (Fig. 3).

Paranasal Sinus Fractures in Closed Head Injury (200 Cases).
Incidence of Damage to Parasella Structures

Paranasal Sinus Fracture	No. of Cases	Hypothalamic Syndromes	Chiasmal Injury	Carotid Aneurysm or Fistula	Cases
Without fracture of the sphenoid	184	7	7	3	14
With fracture of the sphenoid	16	5	3	1	6
Total	200	12	10	4	20*

* Six patients had a combination of these symptoms.

FIG. 3.—Case 2. Operation sketch. Bifrontal flap, division of falx and sagittal sinus, retraction of both frontal lobes. (a) Hole in anterior wall of sella visible after removal of arachnoid of cisterna chiasmatica. (b) Hole plugged with fibrin foam. (c) Patch of fascia lata applied.

For full inspection of the anterior wall of the sella it is necessary to open widely the arachnoid of the cisterna chiasmatica.

The dural tear may be quite small and easily missed, and the proximity of the optic nerves and chiasm, and of the carotid artery, adds to the difficulty of the exploration and of the repair. In two of the three cases in this series that were repaired, the tear was found in the anterior wall of the pituitary fossa beneath one of the optic nerves; in the third case it lay over the tuberculum sellae. In each case the hole in the dura was repaired with a stamp of fascia lata which lay snug and was allowed to adhere by natural processes. We prefer fascia lata to temporal fascia because it is uniform in thickness, more pliable, and more likely to remain and adhere where it has been placed.

This method effectively stopped the rhinorrhoea in our three cases. Four years after the operation all were well and working; there had been no recurrence of rhinorrhoea and no post-operative meningitis.

The main features of the operation are illustrated by the following case.

Case 2

An officer aged 32 was involved in a car accident in Germany on May 10, 1945, and sustained severe facial injuries, including corrosive burns of both eyes, a central block fracture of the maxilla, fracture of the nose and of the right malar and left petrous bones, and fracture of the 6th thoracic vertebra. He also had paralysis of the left sixth and seventh cranial nerves. He bled from both nostrils, and for some hours there was a profuse discharge of blood-stained C.S.F. from his left ear. Smell was grossly impaired at each nostril.

The facial fractures were splinted, after a prophylactic intrathecal injection of 20,000 units of penicillin. Six days later the patient developed profuse bilateral rhinorrhoea and pneumococcal meningitis. He was treated with systemic and intrathecal penicillin and with sulphadiazine, and, after two relapses of his meningitis, finally improved.

The only skull fracture seen on x-ray examination was a fissure in the sella turcica. Several radiographs taken during

the first month after injury showed intracranial air at various times in the subdural space, ventricle, and the cisterna chiasmatica (Fig. 2). The significance of this latter finding has already been mentioned.

Operation to repair the dural tear and stop the rhinorrhoea could not be undertaken for some weeks. The patient was flown to Oxford from Germany two weeks after the accident, and at that time he had a relapse of his meningitis, and was developing collapse of his right lung with bronchopneumonia, which persisted for some weeks. Whenever he was turned on one or other side C.S.F. escaped from one or both nostrils, and it was easy to collect samples for penicillin studies at two-hourly intervals.

By June 22 his general condition was satisfactory for operation and his C.S.F. normal, though the rhinorrhoea was still present. Because radiographs suggested a fracture into the sphenoidal sinus and had also shown air in the cisterna chiasmatica, a wide exploration was carried out, after a preliminary lumbar intrathecal injection of 10,000 units of penicillin. A bifrontal bone flap was turned to the left. The anterior fossa was explored intradurally, and the dura covering the frontal sinuses, orbital roofs, and the ethmoidal regions looked quite normal. The olfactory bulbs and tracts also looked normal, and, though at this stage of his illness smell had partly recovered on the right side, it was clearly necessary to sacrifice them, divide the anterior extremity of the sagittal sinus and the falx cerebri, and retract both frontal lobes in order to examine thoroughly the sellar region (Fig. 3). At first nothing abnormal could be seen, but when the arachnoid of the cisterna chiasmatica was separated from the anterior wall of the sella an area of bare white bone (0.4 cm. in diameter) was disclosed on the right side below the optic groove and above the diaphragma sellae. In the right edge of this bare area, under the medial edge of the right optic nerve, was a hole through which passed a sleeve of arachnoid containing abundant C.S.F. When the arachnoid was cleared a probe could be passed through this hole into the sphenoidal sinus.

The bony hole was plugged with fibrin foam and then covered with a stamp of fascia lata. A second patch of fibrin foam was placed on the anterior wall of the sella between the right optic nerve and internal carotid artery (Fig. 3). The falx was then stitched back into place, and the dura, bone, and scalp were repaired in the usual way.

Subsequent progress was uneventful. The rhinorrhoea ceased immediately and did not recur. The maxillary fracture, which had been treated by internal splinting, healed in good position. The left facial palsy recovered spontaneously and completely, but there remained considerable deafness of the left ear and a scarred but intact ear drum. The spinal fracture, which was treated by a spinal jacket, consolidated with a wedge deformity. His left external rectus made no recovery, and subsequent operations on his extraocular muscles in order to banish the diplopia were only partly successful.

When seen four years after the accident the patient was well and fully employed in administrative work.

In this case the dural tear was limited to the anterior wall of the sella, and, so far as we were able to ascertain, so was the fracture. The rhinorrhoea did not come on until six days after the accident, and was accompanied by pneumococcal meningitis, which relapsed on two occasions in spite of energetic treatment with penicillin and sulphonamides. Much C.S.F. escaped from the nostrils, and with it penicillin. The patient's general condition did not permit of operation until six weeks after the accident, because of his jaw fractures, meningitis, and bronchopneumonia. Anything short of an extensive bilateral intradural exploration of the anterior fossa would have failed to reveal the dural tear, and this operation entailed sacrifice of his already partly damaged sense of smell. The indications for such an extensive operation were the profuse character of the

rhinorrhoea in the absence of radiographic signs of gross fracture of the frontal or ethmoidal sinuses, and the presence of air in the cisterna chiasmatica. The final result may be regarded as highly satisfactory in view of the extensive and severe nature of his injuries.

Tears in the dura may be multiple, hence the surgeon must always satisfy himself that the tear which he finds is the one which is responsible for the rhinorrhoea and that a dural defect further back is not being overlooked. Such a possibility at operation can be envisaged by studying the following case record.

Case 3

In 1938 a youth aged 18 was involved in a motor-cycle accident and sustained a compound depressed right frontoparietal fracture, comminuting both walls of the frontal sinus and the anterior ethmoids on the right side. Special orbital views were not taken, and from the routine views there was no suspicion that the sphenoidal sinus was involved.

The fracture was elevated at another hospital on the day of the accident. Cerebrospinal fluid rhinorrhoea was observed from the *right* nostril on the day after the accident, and it continued for five weeks and then stopped. But a month later profuse rhinorrhoea began from the *left* nostril and continued for six months. The patient was admitted to the Radcliffe Infirmary and exploration was advised, but the day before operation the patient developed pneumococcal meningitis, from which he died 10 days later.

At necropsy, in addition to the signs of meningitis, two distinct fractures were demonstrated. One linear fracture ran down the back of the right frontal sinus, where part of the bone was missing and the dura was adherent to the mucosa; but there was no actual tear of the dura. A second fracture ran across the left optic groove, and here the dura was torn and a hole 0.4 cm. in diameter led into the sphenoidal sinus.

We may assume that the rhinorrhoea from the right nostril followed the fracture behind the right frontal sinus, and healing finally occurred by the dura and sinus mucosa becoming adherent. The left rhinorrhoea was due to the sphenoidal sinus fracture. Owing to septal variations and injury, rhinorrhoea from one side may on occasion result from a contralateral dural tear. It would have been easy to miss this sphenoidal tear with operative exploration limited to the side of the known fracture. We do not advocate bilateral exploration in all cases of traumatic rhinorrhoea. There are some cases of frontal and ethmoidal fracture in which the clinical and radiographic signs provide clear-cut evidence of a unilateral lesion. But whenever there is suspicion that the leakage is through the sphenoidal sinus the exploration should be bilateral.

Summary

In a series of 84 cases of C.S.F. rhinorrhoea following closed head injury, a dural tear over the sphenoidal sinus was found in 11 (13%) and was the only tear in relation to the paranasal sinuses in 5 (6%).

The main clinical characteristic of these five cases was the profuseness of the rhinorrhoea, due to the fact that the tear involved the overlying cistern chiasmatica. Another sign which may be helpful in diagnosis is the radiographic demonstration of air in the cisterna chiasmatica, as in one of these cases.

Neighbourhood signs, such as evidence of damage to the hypothalamic region, optic chiasm, or carotid artery, were present in nearly half the sphenoid cases, but by themselves they do not necessarily indicate a fracture involving the sphenoid sinus. The preservation or loss of sense of smell is likewise no clinical guide.

Operative repair is urgently indicated. The risk of spread of infection intracranially into the basal cisterns is appreciably higher than with fractures involving the other paranasal sinuses.

Operative repair is difficult and requires a bifrontal flap, usually with division of the falx and sacrifice of one or both olfactory tracts. Three patients underwent successful dural repair and have since been followed for nearly four years. There has been no further rhinorrhoea or intracranial infection, and all are well and working.

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ABSENCE OF THE VASA AS A CAUSE OF AZOOSPERMIA

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The treatment of azoospermia due to a blockage in the system of efferent ducts by which the spermatozoa reach the posterior urethra is admittedly very unsatisfactory. The commonest situation for such a blockage is the epididymal canal, and when we consider the small calibre of this canal, its length, and the prevalence of epididymitis, the frequency with which it becomes occluded can easily be understood. The next commonest site for an obstruction is in the ejaculatory ducts, and this is generally the result of recurrent attacks of prostatitis and vesiculitis. Although the vas deferens may also be involved in the infection which brings about an epididymitis, a post-inflammatory stricture of it is uncommon. Genital tuberculosis is an exception to this generalization. In this disease the lumen of the vas is often obliterated, but as the epididymis is still more seriously affected this is of no practical importance. When the vas is obstructed it is usually from trauma, and the commonest cause is damage inflicted on it during the course of an operation such as herniotomy.

To diagnose the exact site of the blockage is not always an easy task. Should there be a clear history of bilateral epididymitis and additional evidence in the shape of areas of induration at the lower poles of both epididymides, then it may be assumed with confidence that the blockage is in these organs. But if there is no such history, and if no areas of induration are found on palpating the epididymides, then it is quite possible that the ejaculatory canals are at fault.

How is this supposition to be confirmed or refuted? Textbooks suggest that catheterization of the ejaculatory ducts should be carried out for this purpose. But unfortunately this advice is much easier to give than to

follow. The openings of the ducts on the slopes of the verumontanum may be so placed that even when clearly seen it is mechanically impossible to pass a filiform bougie along them. One of us (K. W.) remembers witnessing an expert at catheterization at work and was not impressed with the results of his skill. A probe was forced into the lumen of the ducts through a direct-vision posterior urethroscope employing air distension, but such a manoeuvre as this was far more likely to produce a stricture than dilatation. Trauma of the ducts must be rigorously avoided.

Another method of diagnosing an obstruction in an ejaculatory duct is to expose the vas at the neck of the scrotum and to inject into it a solution of indigo-carmin, noting afterwards whether this has passed into the posterior urethra or not. Some urologists have recommended injection of the vasa also, as a therapeutic measure. They believe that the ejaculatory ducts can be opened up thereby, just as the Fallopian tubes are opened up by insufflation. We have never seen a blockage removed in this way, and dislike puncturing vasa purely for diagnostic reasons, not only because of the damage inflicted on a delicate structure but also because of the risk of provoking a descending epididymitis.

If a case of azoospermia is due to blockage of the epididymal canals, the only possible remedy is to carry out a vasa-epididymostomy. Although the results of this operation are very discouraging, we cannot afford to discard a method which in 10% of cases leads to the birth of a child and in 25% to the reappearance of spermatozoa in the semen. If the patient is prepared to accept the gamble and a biopsy has revealed active spermatogenesis in the testes, this operation is justifiable. It can do no harm even if it does no good. Some patients on whom we have operated had previously heard that an alternative method of treatment was available. This was to puncture the testes, withdraw spermatozoa from them, and inseminate with the aspirated fluid. Such treatment is, for reasons into which we do not propose to go, utterly useless. It need not even be considered.

Vaso-epididymostomy

It is useful, but not essential, to give a month's preliminary treatment with gonadotropic hormone in order to stimulate spermatogenesis and to ensure that the epididymal tubes are filled with secretion at the time of operating. After the testicles have been delivered from the scrotum and carefully inspected, the vas deferens is separated from surrounding structures at the level of the head of the epididymis, but great care should be exercised not to imperil its blood supply. The vas is next incised and some 5 to 6 in. (12.5 to 15 cm.) of nylon thread passed down it to demonstrate its patency. This thread is left *in situ* to act as a guide, and attention is then directed to the epididymis. An oval area of the tunica covering the underlying distended tubules is removed, and when the tubules are incised a drop of whitish fluid exudes. This is smeared on to a sterilized coverslip and the presence of spermatozoa confirmed. The finest round-bodied straight needle, carrying 40-gauge steel wire, is passed through the wall of the vas at the lower end of the incision into it and then through the exposed epididymal tubules. Having taken a good bite of these, the needle passes through the vas again, but at the upper end of the incision. It finally emerges through the skin of the scrotum near the root