SPINAL EXTRADURAL CYSTS, CONGENITAL AND ACQUIRED

REPORT OF CASES

OLAN R. HYNDMAN, M.D., AND WILLIAM F. GERBER, M.D.

Department of Surgery, Neurosurgical Service, University of Colorado Medical School,
Denver, Colorado

(Received for publication July 27, 1946)

Cases of congenital and acquired extradural cysts are reported together in this paper with the purpose of comparing them from etiologic and pathologic standpoints.

I. CONGENITAL SPINAL EXTRADURAL CYSTS

Congenital extradural cysts are rare. The last report of a case in the literature was that of Good, Adson and Abbott (1944). In 1934 Elsberg, Dyke and Brewer reported 4 cases and described the cyst with its attending symptoms and signs as a definite clinical entity. The 4 cases represented the incidence in 250 cases of spinal tumor. Adelstein (1941) found only 16 cases reported in the literature and added one of his own. He found that only 3 cases had been reported previous to 1934: one by Schlesinger in 1898, one by Krauss in 1908, and one by Mixter in 1932. In addition to those listed by Adelstein there are 4 cases in the literature as follows: one reported by Turnbull in 1939; one by Mayfield and Grantham in 1942; one by Meredith quoted by Mayfield and Grantham, and one by Good, Adson and Abbott. Our case is apparently the 22nd to be recorded.

The Clinical Syndrome. All of the cases that have been reported are strikingly similar. The lesion manifested itself and was discovered in most instances before the patient was 20 years of age. The cyst is almost consistently located in the mid-thoracic region. Since it is an extradural expanding mass situated for the most part posterior to the cord, it compresses the latter forward and provokes symptoms and signs of such compression: motor weakness in the lower extremities associated with spasticity, hyperactive deep reflexes and the Babinski sign; varying degrees of loss of sensibility to touch, pain and temperature discrimination; some loss of sense of position and two-point discrimination, and in some cases a loss of bowel and bladder control.

A spinal puncture below the lesion reveals a marked increase in protein in the spinal fluid and a partial or complete block when the Queckenstedt test is performed.

Roentgenogram. The roentgenogram of the dorsal spine is of special interest because it has consistently revealed a kyphosis or scoliosis. Cloward and Bucy pointed out this association of kyphosis with the cyst and believed the deformity to be due to impaired venous drainage from the neighboring vertebral bodies. In addition to the kyphosis there is usually a widening of
the spinal canal due to a smooth erosion of the pedicles over several segments.

Thus when the symptoms and signs of a compressive intraspinal lesion are presented in an adolescent patient and these are associated with the type of deformity of the dorsal spine described, one may reasonably suspect an extradural cyst.

CASE REPORTS

Case 1. §68945. F.M., a Mexican male, aged 13, was admitted to the Colorado General Hospital, Denver, Colorado, on April 30, 1945. About 8 months before, he felt that his legs were getting weak. He fell occasionally because of the weakness. He then gradually lost sensation in the legs. Numbness began in the feet and gradually ascended to the abdomen. A severe burn on the skin caused no pain. Lately he had experienced difficulty in starting the urinary stream but still retained adequate control of bowel and bladder function. Lately he had complained of a painful girdle-like band about his waist just above the level of the umbilicus.

Examination. He was well developed and well nourished. The general and neurological examination gave essentially negative findings except for the following: He could barely walk with aid and the gait was markedly ataxic. The Romberg test was markedly positive. The patellar and Achilles tendon reflexes were hyperactive. There was sustained clonus of the ankles on both sides. The abdominal reflexes were absent; cremasteric reflexes present. The Babinski sign was present on both sides. There was a marked loss of all skin sensibilities up to a rather well defined level at about D-8. The usual tests indicated very poor coordination of the lower extremities and alternate motor movement was poorly performed. He had no sense of position of the large toes.

Laboratory Tests. The urine was normal. Blood studies revealed 12.9 gm. of hemoglobin, 9,400,000 erythrocytes, and 8,400 leukocytes of which 58 per cent were polymorphonuclears and 36 per cent were lymphocytes. There was a marked hypochromia and anisocytosis and because of this a biopsy of the marrow of the sternum was taken. It revealed no unusual diagnostic pattern. The blood serology was negative.

Spinal Puncture. Fluid pressure was 90 mm. of water in the prone position. The Queckenstedt test demonstrated a complete spinal block. The protein content of the spinal fluid was 140 mgm. per cent; sugar, 54; Wassermann test, negative.

Roentgenograms. The skull and long bones were negative. The dorsal spine showed a mild scoliosis with convexity to the right. The center of the convexity was at D-5 and 6. The spinal canal was widened and the pedicles were narrowed at D-6, 7 and 8.

Diagnosis. Intraspinal tumor, probably extramedullary and located at about D-7 and 8.

Operation. On May 18, 1945, under avertin anesthesia, the laminal arches of D-7 and 8 were removed. A structure that was taken for dura mater came into view, and it appeared to have the natural color and texture of dura. It was under tension and was incised in the customary manner. Clear transparent fluid gushed forth leaving a hollow cavity with no visible spinal cord. This was at first confusing. A blunt instrument was passed upward and downward within the cavity and met with obstruction at the lower limit of D-4 and the upper limit of D-10. The laminal arches of D-4 to D-10 were removed. It then became obvious that the lesion consisted of a fusiform cyst with pads of fat at both poles (Fig. 1). It was situated in the midline, extradural and posterior to the dura. It was of such a size in its maximum diameter that it could have filled a normal spinal canal, and it severely compressed the dura and spinal cord forward. The cyst was removed without difficulty, having to be severed from the dura at only one attachment the size of a pinhead and close to the lower pole. It was clearly established that there was no fistula or communication with the subarachnoid space. The dura was opened and except for the marked compression of the cord there was no other abnormality of the intradural contents noted. The spinal canal was wider than normal at D-6, 7 and 8 in keeping with the X-ray findings, and the severe compression of the nerve roots intraspinally could easily have accounted for the patient’s complaint of girdle pain. The wound was closed in the usual manner.
Postoperative Course. This was uneventful. At the time he was discharged, June 25, 1935, he had already made considerable recovery of motor power and sensation in the lower extremities.

Pathology. The cyst proved to be an intact completely closed structure, fusiform in contour and presenting an abundance of fat at each end. Both the inner and outer aspects of the wall were strongly reminiscent of dura in respect to color, thickness and texture.

Microscopically the wall was well differentiated into layers that simulated arachnoid, dura and an external well differentiated vascular layer (Fig. 2).

Discussion. Our case presented the usual features of the syndrome of congenital extradural cyst except possibly in respect to girdle pain, which was not a definite symptom in the other cases that have been reported. When the cyst is large and compresses the neighboring spinal nerve roots, as in our patient, girdle pain is a natural consequence.

In respect to etiology, authors have generally subscribed to the theory that the cyst is a congenital diverticulum of the dura. The fact that in some cases the cyst communicated with the subarachnoid space led to the hypothesis that the former resulted from a herniation of the arachnoid through a defect in the dura. Our case presented no weakness or defect in the dura,
and after studying the histology of the cyst wall one of us (O. H.) is of the opinion that these congenital cysts arise from misplaced or detached rests of cells in a manner similar to the development of ganglia about the wrist and epithelial inclusion cysts.

If there is a communicating channel of fair size between the subarachnoid space and the cyst, the pressure in the latter would probably not be as great as that in a closed or non-communicating cyst. The cyst reported by Good, Adson and Abbott communicated with a channel large enough to transmit lipiodol. This may account for the fact that their patient did not develop symptoms and signs until at a much later age than usual.

Differential Diagnosis. There are few lesions that present the combination of symptoms and signs that have characterized the congenital extradural cyst; to wit—it's manifestation during youth, the symptoms and signs of an expanding mass in the dorsal spinal canal which compresses the spinal cord and shows a partial or complete block on the Queckenstedt test, and roent-
genological findings which betray an expanding mass of long standing within
the spinal canal. Hence Elsberg, Dyke and Brewer\(^4\) felt justified in proposing
that such a syndrome identified the cyst as a diagnostic entity.

The roentgenological evidence of an expanding mass within the dorsal
spinal canal that causes widening of the canal and narrowing of the pedicles
with some degree of kyphoscoliosis, without evidence of an intraosseous de-
structive lesion would betray a long-standing, usually benign and probably
congenital lesion. This would limit the diagnostic possibilities consider-
ably.

It would not be impossible for the syndrome to be simulated in all of its
features by syringomyelia. Kyphoscoliosis is commonly associated with
syringomyelia. It is also conceivable that local enlargement of the spinal
canal could be caused by a slow expansion of the spinal cord due to an
intramedullary accumulation of fluid, although we have never encountered
such a case.

Intramedullary tumors may rarely grow to such large proportions and
slowly enough to cause the findings under discussion. Almost as if to teach
us that complete clinical entities are rare, we encountered such a case of
intramedullary tumor (spongioblastoma) just 10 months after studying the
case of congenital cyst reported here.

Since the syndrome in all of its features so closely simulated that of con-
genital extradural cyst and since this type of tumor itself is rare and inter-
esting, we are including the report in some detail.

The rarity of this neoplasm is indicated in the literature briefly as follows:
Ford,\(^7\) in analyzing Dandy’s series of cord tumors, found only one question-
able spongioblastoma in a child of 14. In Elsberg’s\(^8\) series of 253 spinal neo-
plasms there were only 26 primary gliomas of the cord and there were no
spongioblastomas in this group. However, 6 cases were cited in the literature:
two by Kernohan,\(^9\) three by Elvidge, Penfield and Cone,\(^9\) and one by Foerster
and Bailey.\(^6\)

Case 2. Intramedullary Spongioblastoma Simulating Extradural Cyst. W.M., a Mexican
male, aged 18, was admitted to the Colorado General Hospital, on Feb. 2, 1946. About 17
years before admission the patient felt that his legs were getting weak and he did not sense
pain when he pinched the skin of his legs. Six months later his mother noted scoliosis of the
dorsal spine. On Nov. 26, 1945, because of the weakness of the lower extremities and the
“crooked” spine, he was taken to the Spears Sanitarium, a chiropractic institution in Denver,
where he was given chiropractic treatments and colonic irrigations. After about 6 weeks in
the sanitarium the patient became almost completely paralyzed below the level of D-8. After
another 3 weeks he was discharged from the sanitarium and admitted to the Colorado General
Hospital.

Examination. He presented a complete loss to all modalities of sensation below D-8 and
a partial loss up to the level of D-8. All motor function was paralyzed below the waist except
for the fact that he could wiggle both large toes very slightly. There was complete loss of bowel
and bladder control.

A spinal puncture at the 3rd lumbar interspace revealed a complete block on the Quecken-
stedt test and a high protein content in the spinal fluid.

Roentgenogram. The dorsal spine showed a moderate scoliosis to the right. The spinal canal
Fig. 3. Case 2. Drawing of the intramedullary neoplasm, which enlarged the spinal cord uniformly from D-3 to below L-1. The pia remained intact everywhere. The slow growth of the tumor resulted in widening of the spinal canal, narrowing of the pedicles, and scoliosis, so that the syndrome closely simulated that of congenital extradural cyst. C, intramedullary cyst containing chocolate-colored fluid.

In a lateral view there was a smooth pressure erosion of the bodies of the vertebrae from D-8 to D-12.

Diagnosis. Since we were dealing with an intraspinal expanding mass in a boy of 18 extending over a number of segments and of long enough standing to cause scoliosis and a widening of the spinal canal, the diagnosis was naturally that of congenital extradural cyst.

Operation. Ultimately the laminal arches from D-3 to D-12 inclusive were removed. The spinal cord was uniformly enlarged throughout the entire exposure, being 1 inch in diameter in the mid-dorsal region (Fig. 3). The pia was everywhere intact. An incision was made in the posterior median fissure. The tissue was uniformly brown and there was nothing that grossly resembled cord tissue. A cyst containing chocolate-colored fluid was present (Fig. 3, C). A biopsy was made.
Pathology. Microscopical study revealed the cellular characteristics of spongioblastoma with evidence of old hemorrhage (Fig. 3, inset).

Course. The patient recovered from the operative procedure and although the cord appeared to have been entirely destroyed by neoplasm, he could still voluntarily move both large toes as he did before operation.

Although spongioblastoma is an infiltrating glioma, it usually has a long life history. If it occurs in the brain stem, it usually enlarges the latter uniformly and while tumor cells infiltrate the tissue everywhere, they appear to do so without much destruction of the nerve cells and fiber tracts until late in its history.

II. ACQUIRED EXTRADURAL CYSTS

We have been unable to find a report of this lesion in the literature. The two cases reported here are illustrative and are the only cases of their kind we have encountered.

CASE REPORTS

Case 3. #60779. B.11[., a white girl, aged 16, was admitted to the Colorado General Hospital, on May 4, 1943. She complained of pain radiating down both legs of about 10 weeks duration.

On examination she presented an absent Achilles reflex on the right and hypalgesia on the lateral aspect of the left leg. Blood and urine were negative.

Spinal Fluid. The Queckenstedt test gave a normal rise and fall,* but when the pressure in the spinal subarachnoid space was increased, the pain radiating down the lower extremities was aggravated. The specimen of spinal fluid was slightly yellowish. It contained 2,350 mgm. per cent of protein and 45 mgm. per cent of sugar.

On May 22, 1943 three cc. of lipiodol were injected into the subarachnoid space and roentgenograms showed a complete block at L-2.

1st Operation. On June 4, 1943, a laminectomy from L-1 to L-3 inclusive was performed by the neurological surgeon in charge. When the dura was opened, a tumor was encountered. It measured 3 × 1.5 × 1.3 cm. and was free except for attachment to a nerve root. After severing the nerve root proximal and distal to its fixation point in the tumor, the latter was lifted out in toto. Hemostasis was effected with Cushing silver clips and the dura was closed with a continuous cotton suture. The muscle layers were approximated with interrupted chromic catgut and the fascia with cotton sutures.

Histological Diagnosis. Perineurial fibroblastoma.

Course. Recovery was uneventful and the patient considered herself well until November 1944, about 17 months after the first operation. At this time she experienced a recurrence of the pain down the lower extremities associated with pain in the right hip which became quite severe.

Second Admission. She was readmitted to the Colorado General Hospital on June 1, 1945. Weakness of the lower extremities had progressed to the point where walking was considerably impaired. The Achilles reflex was still absent on the right, and there was marked hypalgesia in the L-3 distribution on both sides, being more marked on the left. There was some weakness of the bladder sphincter, resulting in dribbling.

Spinal puncture and Queckenstedt test did not reveal the presence of a block, but the needle was probably placed above the lesion. The specimen of fluid was not sent to the laboratory.

Lipiodol study was repeated and the roentgenogram showed a complete block at the level of L-4, the lower level of the block.

Impression. There was no question concerning the recurrence and progression of the

---

* The spinal needle may have been placed just above the tumor. A later puncture at the 5th lumbar interspace revealed a block on the Queckenstedt test.
symptoms and signs indicating a compressive or destructive lesion at L-4, and the lipiodol study confirmed the fact. It was, however, difficult to conceive how a benign perineurial fibroblastoma which had been completely removed could recur.

2nd Operation. On June 26, 1945 the old wound was re-opened. At the level of L-2 and L-3 an extradural cyst was encountered, directly posterior to the dura. When it was incised, clear cerebrospinal fluid gushed forth. The inner aspect of the cyst presented a smooth glistening wall. The inside dimensions were about 2×3 cm. The outer aspect of the cyst was continuous with the surrounding scar tissue and muscle. The base of the cyst was attached to dura and severely compressed the latter ventralward. There was a tiny pin-hole fistula in the old line of incision in the dura. The fistula was directly adjacent to a silver clip which had been left in place on the cut edge of the dura at the first operation (Fig. 4). Spinal fluid could be seen seeping through the tiny fistula into the cyst. The cyst wall was excised and freed from its attachment to the dura. The silver clip was removed and the dura resutured. Inspection of the cauda equina showed that there was no recurrence of tumor.

Course. Recovery was uneventful and at the time of discharge from the hospital on July 11, 1945 she had made remarkable improvement.

Pathology. The excised cyst wall presented the gross characteristics of scar tissue. The inner aspect was smooth and glistening, and the outer aspect was ragged. There were no separable layers or planes of cleavage.

Microscopically the inner wall was composed of dense fibrous (scar) tissue and appeared to be lined by mesothelium. The wall of scar tissue was continuous with surrounding muscle (Fig. 5), and should be compared with the well differentiated cyst wall in Fig. 2.

A small or “daughter” cyst was found in the wall of the large cyst. It is interesting because it reveals to some extent the mechanism of formation of such cysts. The cavity becomes enclosed by a wall of scar tissue, and the muscle contained within the cavity breaks apart. The fibers separate and fragment. The elements of inflammation and necrosis are not demonstrable (Fig. 6).
Case 4. #427656. O.C., a white male, was first admitted to the University Hospital, Iowa City, Iowa, on July 3, 1942. He had been progressively losing strength in the upper and lower extremities for 18 months. For 6 months he had been unable to walk. He had almost completely lost control of bowel and bladder function.

Examination revealed the following significant positive signs: Some stiffness in the neck. Loss of voluntary movement of the lower extremities with spasticity, hyperactive deep reflexes and Babinski sign on both sides. The general strength of the left hand was about 50 per cent of that on the right, and there was atrophy of the intrinsic muscles of both hands. All modalities of sensation were markedly impaired up to the level of the nipples, and there was patchy analgesia on the left hand and forearm.

Spinal puncture revealed an almost complete block on the Queckenstedt test and the fluid was xanthochromic. Lipiodol (5 cc.) was injected into the subarachnoid space by cisternal puncture, and a roentgenogram showed that there was a complete block at the level of the 5th cervical vertebra.

1st Operation. Upon the diagnosis of a cervical spinal tumor a laminectomy was performed on July 4, 1942. The laminal arches from C-4 to D-2 inclusive were removed. A large rather vascular meningioma was uncovered. It extended from the level of C-5 to D-1. It was extradural and to the left side of the cord, severely compressing the latter to the right. It was removed with some difficulty since it had extended some distance through the intervertebral canal at C-7 on the left. The 8th cervical and 1st thoracic roots on the left were imbedded in the tumor to such an extent that it was necessary to sacrifice them. As near as could be ascer-
tained by gross inspection, I felt I (O.H.) had removed all of the tumor, but due to its friable nature and the necessary piecemeal removal judgment could not be conclusive. A slight tear was made in the dura where the 7th cervical root on the left joins the spinal dura. The rent was in the axilla of the root, and although a suture was placed, the repair was not water-tight.

**Histological Diagnosis.** Angioblastomatous meningioma.

**Course.** The wound became infected with *Staphylococcus aureus*, and spinal fluid drained from it for almost 3 weeks. It then healed without further complication, and he was discharged on Aug. 3, 1942. He made rapid and marked recovery from the paralysis to the point where he could walk without aid. In January 1943, about 6 months after removal of the tumor, the former symptoms and signs of paralysis began to recur.

**Readmission.** On Mar. 24, 1943 he was readmitted to the hospital in much the same condition as he presented on the 1st admission.

**2nd Operation.** Under the impression that the tumor had recurred, the wound was re-explored. A cyst posterior to the dura was disclosed. It was about the size of a golf ball, and when it was incised, clear spinal fluid gushed forth indicating that it was under considerable tension. The inner lining of the cyst was smooth and glistening, and its outer aspect was continuous with scar tissue and muscle. A small pin-hole fistula was found at the axilla of the 7th cervical root on the left where the dura had been torn at the first operation. The fistula admitted spinal fluid to the cyst but did not allow its return to the subarachnoid space. The fistulous opening into the cyst was somewhat slit-like with compressible lips strongly reminiscent of...
the ureteral orifice in the urinary bladder. The cyst wall with adjacent scar tissue was dissected out. The fistula in the dura was excised and the latter repaired. It was obvious that the cyst had severely compressed the spinal cord and was responsible for the recurrent paralysis. A careful search revealed no evidence of recurrent tumor.

Microscopically, as in Case 3, the cyst wall was found to be composed of dense fibrous tissue with probably a mesothelial lining. There was no evidence of inflammation.

Course. The patient again made considerable improvement for 4 months at which time the symptoms and signs of paralysis of the upper and lower extremities began to recur for the second time. The patient is no longer under the care of one of the authors (O.H.), but re-exploration was advised. It has not yet been done. Since there was no evidence of recurrent tumor at the second exploration, it is possible that another extradural cyst has developed by the same mechanism that was responsible for the first.

Discussion. It is clear that the causal factor for the recurrence of symptoms and signs in these two cases was an acquired extradural cyst. The cyst was a natural consequence of a persistent tiny fistula leading from the spinal subarachnoid space. It was also clear on close inspection that the silver clip on the free edge of the dura in Case 3 was responsible for the persisting fistula inasmuch as the dural margins could not seal completely about the foreign body.

It is easy to conceive how spinal fluid could find ingress into the cyst cavity and be forced into it when the patient strained, coughed, sneezed or did anything that would raise the spinal pressure. It was equally obvious that the intracystic fluid would have considerable difficulty in finding egress back into the subarachnoid space through the fistula. In short, such a fistula serves as a one-way valve with the consequence that fluid accumulates in the cyst cavity under ever increasing pressure.

It is a well known fact that with a persisting spinal fistula admitting spinal fluid into the soft tissue, the accumulation of fluid soon becomes encased by a non-absorbing wall. The smooth glistening appearance of the wall suggests a mesothelial lining. It is because of this development that the construction of fistulas between the ventricles or subarachnoid spaces and soft tissues are not practical or of permanent value in the treatment of congenital hydrocephalus.

It is probably the rule that closures made in the dura are not immediately water-tight, and if a drain is left in the soft tissue wound for a day or two, considerable spinal fluid will escape from the wound. The flow will usually cease in 3 to 5 days, indicating that the dural wound has healed sufficiently to become water-tight. If the wound is not drained, spinal fluid no doubt escapes into the soft tissues. The latter, and particularly muscle, will absorb a considerable amount of the fluid over a period of days. Eventually, however, if fluid continues to escape into the soft tissues, it will become encysted by a non-absorbing wall. In the 2 cases presented here the circumstances were such that fluid accumulated in the cyst under increasing pressure. Hence the cyst assumed considerable significance because by compressing the cauda equina or the spinal cord at the site from which a neoplasm was removed, it was responsible for a recurrence of the previous symptoms and
SPINAL EXTRADURAL CYSTS

signs. Sufficient time had elapsed after the operation to arouse a suspicion that the tumor had recurred. Since the tumor in both of these cases was benign, there was no hesitancy in advising re-exploration. It is conceivable, however, that similar cases might be encountered where the pathology is that of malignancy or is doubtful. In such a case, the recurrence of symptoms 4 or 5 months after operation might provoke the impression of a hopeless prognosis and advice against re-exploration. In any case, since the development of an acquired extradural cyst, such as reported here, is a distinct possibility, it should be given proper consideration in diagnosis. Certainly if intradural operations are done for reasons other than removal of a neoplasm and the symptoms and signs of cord compression later develop, this lesion should be included among the possible causes.

Fortunately, it is very uncommon for a subarachnoid fistula, either intracranial or intraspinal, to persist in the absence of infection and dural wounds normally heal. The results of the experience reported here teach that dural tears or incisions about the junctional zone of a root, and especially in its axilla, may not heal so readily. It also becomes rather obvious that leaving silver clips on the sutured margin of the dura, especially the spinal dura, is bad practice and moreover unnecessary.

SUMMARY AND CONCLUSIONS

One case of spinal extradural cyst, congenital, is reported. It is the 22nd case on record. In essentially all of its clinical characteristics it conformed with the other cases reported. The early onset of symptoms and signs of an intraspinal compressive lesion at about the mid-dorsal region associated with the roentgenological findings of kyphosis or scoliosis and widening of the spinal canal is sufficient to warrant a consideration of the lesion. A study of the pathology indicates that the cyst probably arises from a misplaced rest of cells. If the onset of paralysis is insidious and the cyst is removed, the prognosis should be good.

A case of spongioblastoma of the spinal cord is presented in relation to differential diagnosis because the case was indistinguishable clinically from the syndrome of spinal extradural cyst.

Two cases of acquired extradural cyst are reported. One developed in the low cervical region, manifesting itself about 6 months after removal of an extradural meningioma. The cause was a small persistent fistula in the axilla of the junction of a nerve root and spinal dura.

In the other case a cyst developed in the lumbar region, manifesting itself about 17 months after removal of an intradural perineurial fibroblastoma. The cause was a small persistent fistula in the old line of dural incision and at a point where a silver clip had been applied to the cut margin of dura and allowed to remain when the latter was sutured.

Cases of this kind, though probably rare, are instructive. If symptoms and signs of an intraspinal compressive lesion occur or recur after an operation in which the subarachnoid space is opened, one should consider the
possibility of acquired extradural cyst. The lesion is benign and the prognosis good after its removal and repair of the fistula leading into the subarachnoid space.

REFERENCES