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THE HAZARDS OF LUMBAR PUNCTURES

BY

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THE HAZARDS OF LUMBAR PUNCTURES

The lumbar puncture has been used extensively as a diagnostic and therapeutic procedure since Quincke devised it in 1891. While the mortality rate of the procedure has always been extremely low, the non-fatal complications have ranged from reported incidence of one to forty percent. Numerous techniques and types of equipment have been developed and contraindications elicited in order to eliminate the hazards of the lumbar puncture. However, no one technique or one type of equipment or even one set of contraindications has ever been established. Accordingly, the incidence of complications has varied greatly both in number and in severity since the inception of the test.

In the following pages the hazards of the lumbar puncture will be elicited and discussed, and a technique set forth which is thought to be the most efficient in the reduction of these hazards.

INDICATIONS FOR LUMBAR PUNCTURE

The accepted indications for the procedure are many and could probably be enumerated best as follows:

1. Poliomyelitis
2. Epidemic meningitis
3. Symptoms of meningeal irritation
4. Suppurative otitis media with signs of intracranial extension
5. Evidence of progressive impairment in function of intracranial or intraspinal structure such as:
 - a. cranial nerve paralysis

- b. root pains
- c. disturbances of pupillary, tendon and plantar reflexes
- d. hemiplegia
- e. aphasia
- f. apraxia
- g. dementia in younger people and with signs of organic involvement
- h. dementia paralytica
- i. multiple sclerosis
- j. mental and cerebral symptoms with fever of obscure origin
- k. comatose states
- l. syphilis
- m. transverse lesions of the cord
- n. deviations from the usual course of a sciatic neuritis, especially bilateral
- o. injection of sera and medications
- p. spinal anesthesia
- q. injection of media for radiological techniques
- r. spinal drainage

However, it must be emphasized that when any of these indications are employed, an adequate neurological examination is mandatory preceding the performance of the lumbar puncture.

ANATOMICAL

In order to appreciate properly some of the hazards and their mechanisms it is helpful to review what the anatomical pathway of the spinal needle is as it passes toward the subdural space.

In preparation for the procedure, the patient is placed in a position of hyperflexion either in the upright sitting position or preferably on his side. The needle as it is introduced is angled slightly anteriorly in order to compensate for the flexion and to thus avoid impingement on the bone.

The most common approach is a midline puncture in the interspace between the third and fourth lumbar vertebrae. This site is most easily identified by drawing an imaginary line from the top of one iliac crest to the other. Careful palpation will reveal the depression between the spines of the vertebrae. In the adult it is safe to do a puncture as high as the second intervertebral space because the end of the spinal cord lies at the level of the first vertebra. In the child, however, the cord lies as low as the inferior border of the third lumbar vertebra, therefore a puncture higher than the third interspace is contraindicated.

In the midline spinal tap, the needle first passes through the skin and subcutaneous tissues. The piercing of the skin is actually the most painful part of the procedure, and is pain which may be alleviated by anesthetizing the area with one percent procaine solution. The needle next encounters a sense of resistance which is attributed to its passage through the supra spinal ligament and the interspinal ligament.

When the epidural space is reached, it is denoted by a decrease in resistance owing to the fact that it is a space in which negative pressure exists. Finally the dura-arachnoid is pierced and this is noted by variously described sharp "give" or "snapping" sensations.

In some elderly patients the spinal ligaments may be partially calcified and thereby impart a deflection to the needle. In order to avoid this deflection, a lateral approach is sometimes used. In this approach the spinal needle does not pierce the supraspinal ligament and interspinal ligament, but rather goes through the ligamentum flavum near the midline.

HAZARDS DUE TO FAULTY INTRODUCTION OF THE SPINAL NEEDLE

1. The bloody tap

Probably the most commonly encountered mechanical hazard is the so-called bloody tap. In itself, the bleeding is insignificant and no after effects are noted. A hematoma may form in the subarachnoid space, but this is of little significance. The main difficulty lies in the fact that the diagnostic results of the puncture are obliterated. The presence of the extraneous blood in the spinal fluid falsifies the true results of both the chemical and the cytological studies. Although the fluid as it is withdrawn may soon "clear up", it is impossible to know when the fluid is completely free of blood, and thus the diagnostic result can never be considered accurate. Reintroduction of a different needle is the only solution and this not only adds to the local trauma, but, as will be seen later, adds to other hazards such as the spinal headache.

The mechanism of the bloody tap is that the needle either pierces the blood vessels in the subarachnoid space, or the needle is advanced too far and enters into the epidural network which is most developed anteriorly. It must be remembered that a homogeneously bloody fluid should not be thrown away but first examined to exclude the possibility of a subarachnoid hemorrhage.

2. Collapse of the intervertebral disc.

The collapsed disc is another traumatic effect due to the spinal needle itself. Hyperflexion of the spine, as it is in the position assumed for the puncture, increases the danger of this complication in two ways. First, it directs the spinal needle into the intervertebral space, and secondly, flexion increases the disc pressure and also causes a slight bulging of the disc into the neural canal. A minor puncture of the disc may result in a leakage of nuclear material through the annulus fibrosus, and cause back pain and disability due to the partial collapse of the disc and the marginal proliferation of the adjacent vertebral bodies. This may be done by either continuing through the neural canal and thus into the intervertebral disc, or by a deflected needle which passes laterally to the dura and finally into the annulus fibrosus and into the disc lateral to the reinforcing posterior longitudinal ligament. This complication is likely in the child due to the greater resilience, the greater tension, and the more fluid nature of the palposus.

However, if the needle is correctly directed cephalad, it will no longer be in line with the disc but will instead impinge upon the posterior surface of the superior vertebral body when it is inserted

too far, and thus prevent a puncture of the disc.

3. Paresthesias.

Although a needle introduced into the space between the third and fourth vertebral bodies will not hit the spinal cord itself in an adult, it is entirely possible for the needle to strike one of the nerves of the cauda equina and cause pain and other paresthesias radiating along the distribution of the afflicted nerve. True disability is exceedingly rare, but the resulting paresthesias may last as long as several months.

4. Broken needle.

A rapidly introduced spinal needle of small caliber may be broken by impingement on the bony structures or possibly by striking an extremely resistant and calcified spinal ligament. A needle deflected superiorly may hit the lamina of the vertebra above the site of puncture while an inferiorly deflected needle may strike the spine or lamina of the vertebra below the site. It is also possible to go too deep and strike the body of the vertebra itself. A broken needle may require surgical removal which is an excessively high price to pay for lack of caution on the part of the operator.

5. Cord damage.

A puncture done higher than the second interspace in the adult and higher than the third interspace in the child may result in direct damage to the spinal cord itself. The results, of course, are the results of severance of whatever portion of the cord has been involved. Several cases of neurogenic bladders have been reported due

to lumbar puncture. It might be mentioned that in extremely rare cases a segmental nerve outside the subarachnoid space has been traumatized.

6. Traumatic arthritis.

Repeated striking of a vertebra with the needle or excessive pressure applied to an impinged needle has been thought in several cases to be the cause of a localized arthritis. However, most arthritic-like complaints following lumbar puncture have usually been accredited to psychogenic factors.

7. Dry tap.

While not truly a hazard as such, the so-called "dry tap" has frequently been the cause of an unsuccessful procedure. Aside from cases in which the spinal canal is occluded above the site of puncture, the dry tap is due to the needle not being located properly in the spinal canal. When the fluid is withdrawn, the dura-arachnoid is drawn toward the eccentrically placed needle and sometimes occludes the bevel of the needle thus preventing the withdrawal of the fluid.

HAZARDS OF INFECTION

1. Meningitis

An extremely dangerous complication of a lumbar puncture is bacterial meningitis. The introduction of the bacteria to the meninges can theoretically be accounted for in four ways.

a. The introduction of unsterile apparatus is one possibility. Along with this should be included contamination from the hands of the operator and the use of procaine solution other than that con-

tained in sterile ampules. Although this is a rare method of inoculation, it should always be considered and steps taken to eliminate it. Routinely, sterilization of equipment and the use of sterile procaine solution contained in individual ampules should be employed. The hands should be washed, sterile gloves donned, and a face mask worn.

b. The skin of the back over the site of puncture is another source of bacteria. When the spinal needle pierces the skin it carries forward with it cells and possible bacteria. While no solution will completely sterilize the skin, the use of an iodine and alcohol preparation will reduce the superficial bacteria and lessen the chance of introduction of infection in this manner.

c. A septicemia at the time of the lumbar puncture provides another mechanism for the infection of the meninges. The needle may pass through the capillaries or venous channels of the subarachnoid or epidural networks and carry the contaminated blood into the meninges and thereby initiate the meningitis.

d. A fourth possibility advanced by some writers is that the lowering of the spinal pressure by the lumbar puncture somehow lets down the blood-brain barriers, and in the presence of a septicemia, bacteria may be admitted to the meninges.

Meningitis is in the main "preventable" infection. The application of good aseptic technique will eliminate the greater share of this hazard.

2. Acute spinal epidural abscess.

The infection of the epidural space is usually accomplished by either a direct spread from a contiguous infected area, usually an

adjacent rib or vertebra, or by a metastatic hematogenous infection, the latter method being accomplished by the mechanisms described for meningitis. Trauma is an unusual possible etiology. The organism is commonly staphylococcus aureus --- an organism not commonly causative of meningitis. The acute spinal epidural abscess is of extremely rare occurrence.

3. Sinus tract.

The withdrawal of the spinal needle from the spinal canal, especially without replacement of the stylet, may cause spinal fluid to be carried to the outside. Should the fluid be infected, a troublesome sinus tract can be established.

HYDRODYNAMIC HAZARDS

1. Spinal headaches.

The most common and the most controversial of lumbar punctures hazards is the spinal headache. There are as many theories and conflicting results as there are writers on the subject. However, most of this is understandable. The evaluation of a headache is necessarily subjective and that fact alone can largely account for the reported incidence of post spinal headaches varying from one to forty percent. Also, the unavoidable suggestion by the data seeker is a factor that must be considered in the final results.

The most widely accepted etiology of spinal headaches is the leakage theory. The cerebrospinal fluid leaks through the puncture site and leads to changes in the spinal fluid dynamics. There is a loss of the water cushion supporting the brain, and this produces pain due to

pressure or traction (or both) on the sensitive brain structures and larger vessels. The leakage is encouraged by the negative pressure in the epidural space, and by the increase of the cerebrospinal fluid pressure at the site of puncture when the patient assumes the erect position. The puncture wound in the dura takes approximately seven to ten days to heal. However, most headaches have their onset in the first three days, and are generally gone by the end of a week, but may last several weeks. The headaches may be of any type but are most commonly frontal and bilateral in nature. They may vary in severity from mildly annoying to severely incapacitating. Sitting up, as does activity, usually aggravates the headache. The Trendelenberg position usually helps relieve it.

The psychological factor also plays an important part in both the number and the severity of the post spinal headaches. This factor will be discussed in greater detail in a succeeding section.

In accordance with the assumed etiology, the prevention of spinal headaches lies in the prevention of the leakage. The use of small needles, either #22 or #20, will decrease the size of the opening in the dura. If the bevel of the needle is introduced parallel to the longitudinal fibers of the dura, it will tend to separate the fibers rather than cut them and thus decrease leakage by permitting better closure of the dural sac after withdrawal of the needle. Multiple punctures are therefore also undesirable. The amount of cerebrospinal fluid withdrawn should be limited to only what is actually needed. An average withdrawal of about ten to fifteen cubic centimeters of fluid is

desirable. Following the tap the patient should remain in bed in the horizontal position for a minimum of twelve hours. The use of a pillow is to be denied and a slight Trendelenberg position may be employed.

2. Herniation into the foramen magnum.

The danger of herniation of the brain exists when lumbar punctures are performed in the presence of increased intracranial pressure. Two groups of lesions in which a lumbar puncture may give rise to lethal complications are: first, cerebral and cerebellar tumors, and secondly, lesions of the cerebral circulatory system. The herniation gives rise to increased pressure on the respiratory center, and this leads to sudden apnea and possibly death in a matter of minutes. A puncture done under conditions of increased pressure may also give syncope, apoplectic form ictus, and cerebral hemorrhages. However, despite the existence of these serious complications, a lumbar puncture can be safely performed in cases of increased intracranial pressure without much chance of damage. Under such circumstances the patient should always be in the hyperflexed, lateral prone position and never in the sitting position. A number twenty-two needle with the bevel facing laterally is introduced and the stylet removed with extreme care. Five centimeters or less of cerebrospinal fluid are then withdrawn as slowly as possible. Following the procedure the patient should remain in bed and on his back for twenty-four hours. When a lumbar puncture is done under such conditions, the physician should be prepared to inject saline into the spinal canal in cases of complications, and a neurosurgeon should be

ready to do a decompression if necessary.

3. Sixth nerve palsy.

The most likely etiology of this rare complication is a mechanical one. The use of a large needle causes a rapid loss of a comparatively large amount of spinal fluid. The brain is suddenly deprived of its water cushion, and sags with a resulting strain being placed upon whichever sixth nerve is uppermost. The nerve is stretched and a paralysis of the external rectus occurs on the side opposite from that on which the patient was lying.

PSYCHOLOGICAL HAZARDS

Psychological factors are contributory to both the number and severity of some lumbar puncture sequelae. This is especially true in the case of the post spinal headache. Although the leakage theory plays the major role in the production of these headaches, several things may be said regarding the psychological contributions. While age and sex seemingly have no effect, it has been noted that people of average intelligence suffer a greater number and also more severe reactions than people of above average or superior intellect. Patients with chronic anxiety or hypochondriacal tendencies tend to have a greater incidence of headaches but with no increase of severity. Those who are either elated or depressed at time of the lumbar puncture are found to suffer fewer and less severe after effects. If rejection of the procedure exists, a greater number of sequelae can also be anticipated in the post spinal period. When a reaction takes place in patients who know of the procedure or who have knowledge of the experiences of others with the spinal puncture, it may be expected that the result will be more severe in these people.

The approach to the patient and the manner and attitude in which the test is conducted is all important in the reduction of the psychological hazards of the lumbar puncture. The doctor should explain the purpose of the procedure to the patient, omitting all the anatomical considerations and mention of the spinal cord. He should reassure him and talk to him while the tap is being done. All mention of possible sequelae should be eliminated, and all suggestive influences removed as much as possible.

CONCLUSIONS

The hazards of lumbar punctures in the great majority of cases are preventable hazards -- the prevention of which lies in the application of proper techniques. The patient should be prepared psychologically for the ensuing procedure, and an attempt should be made to keep him at ease throughout the test. Sterile technique and sterile equipment is always to be employed, and in keeping with this the physician should wear a face mask as well as sterile gown and gloves. An iodine preparation is first given to the skin followed by the application of alcohol. The third lumbar interspace is normally the chosen site, but if need be, the second lumbar interspace can safely be used in the adult. If so desired, the site of puncture may first be anesthetized with procaine obtained from sterile individual ampules. With the patient preferably in the lateral hyperflexed position, a #22 or #20 spinal needle, angled slightly cephalad and with the bevel facing laterally, is introduced through the skin in the midline. The needle should be advanced slowly until it enters the spinal canal. The stylet is to be

withdrawn slowly and the smallest usable specimen collected. The stylet is then replaced and the spinal needle withdrawn.

Following the lumbar puncture, the patient is to remain in bed in the horizontal position without a pillow for a minimum of twelve hours.

With the use of such a technique, lumbar puncture may be performed on any type of patient with a minimal incidence of sequelae.

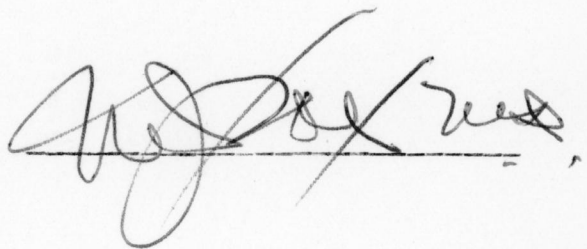
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Approved:

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