

We postulate that the hypoxia of the patient described in the present communication was a manifestation of neurogenic pulmonary dysfunction. A significant and confirmed decrease in arterial oxygen tension occurred abruptly and immediately following a probable cerebral insult that caused objective neurologic changes. No associated primary respiratory or circulatory change that could explain the hypoxia could be demonstrated. Possible factors involved in producing localized cerebral injury include embolization of air or atheromatous material and a period of carotid occlusion. Specific neurally mediated alterations in pulmonary function responsible for the large pulmonary shunt that must have existed in this patient when his alveolar-arterial oxygen tension difference was greater than 600 mm Hg are not well established.<sup>1</sup> This case is presented because we have been unable to find any other report in which a documented change in pulmonary function was temporally so closely associated with an identifiable cerebral injury under clinical conditions in man. It is possible that if arterial blood gases were systematically monitored in comparable clinical situations, transient neurogenic pulmonary dysfunction might be encountered relatively frequently.

## The Psoas Compartment Block

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Analgesia of the inferior segments of the lower limb can easily be achieved by a femoro-sciatic block, but a similar possibility, other than spinal or epidural analgesia,

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has not been developed for the thigh because of the multiplicity of its nerve supply.<sup>1,2</sup> Winnie<sup>3</sup> has described an anterior inguinal approach for paravascular anesthesia of the lumbar plexus, and has also suggested the possibility of a lumbar paravertebral method of injecting the lumbar plexus.

We have developed an approach to the lumbar plexus based on the fact that most of the branches of the lumbar plexus and some of the sacral plexus supplying the thigh are found close to each other in the region of the fourth lumbar vertebra in what we call the "psoas compartment." Here the plexus can be reached by a single injection.

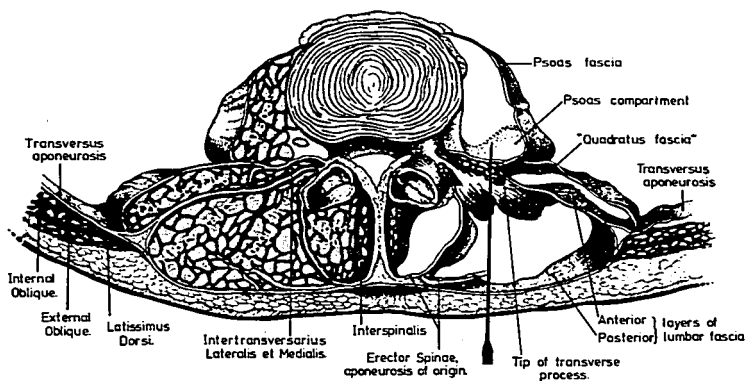


FIG. 1. Inserted needle, showing anatomic relation to the psoas compartment.

#### ANATOMIC CONSIDERATIONS

The upper segments of the limb are innervated mainly by branches of the lumbar and sacral plexuses: the lateral femoral cutaneous nerve of the thigh (L2-L3) laterally, the femoral nerve (L2-L4) anteriorly, and the obturator (L2-L4), and genito-femoral (L1-L2) medially from the lumbar plexus, and the sciatic nerve (L4-S3) and other smaller branches posteriorly, from the sacral plexus.

The lumbar plexus is formed by the ventral rami of the first, second, third, and major part of the fourth lumbar nerves. It is located deep in the substance of the psoas major muscle, in a kind of compartment formed by the muscle and its fascia anteriorly, the bodies of the lumbar vertebrae medially, and the transverse processes of the same vertebrae, the intertransversary ligaments and muscles, and the quadratus lumborum muscle posteriorly.

The femoral nerve emerges laterally to the psoas and the obturator medially to it, descending in the depression between the psoas and the L5 vertebra. Medial to the obturator nerve and deep in the same depression descends the branch of L4 to merge into L5 to form the lumbosacral trunk. This trunk continues its course over the ala sacra to enter the pelvis, and form the sacral plexus together with the ventral rami of S1-S3 nerves.

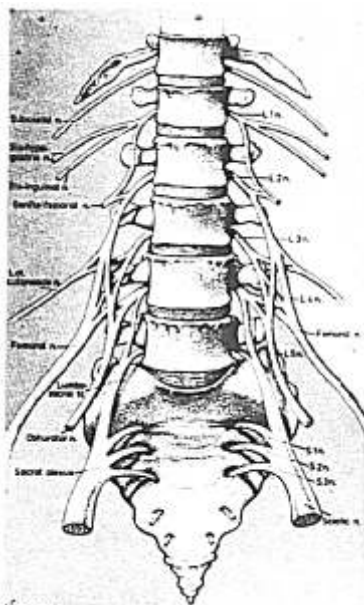


FIG. 2. Schematic shows the lumbar and sacral plexuses and the relations of their nerves to the psoas compartment.

At the level between the transverse processes of the fourth and fifth lumbar vertebrae a group of nerves innervating the upper segment of the lower limb is found in close proximity. They are, from laterally to medially: the lateral cutaneous nerve of the thigh, the femoral nerve, the genitofemoral nerve, the obturator, and the lumbosacral trunk.

MATERIAL AND METHODS

The course of the needle during its insertion, and its anatomic relations to the psoas and the branches of the lumbar and sacral plexuses, were tested in 60 dissecting-room cadavers and 25 dry skeletons. As a control, 10 cadavers were x-rayed after injection with 30 ml contrast medium (see fig. 3)



FIG. 3. An A-P view of the injection of 30 ml contrast medium in the psoas compartment. The tip of the needle reached lateral to disc L4-L5. The injected material spread upwards to the origins of the psoas (L2-L5) and descends with the muscle into the pelvis.

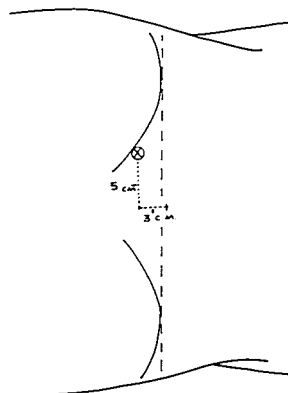


FIG. 4. Surface measurements for the point of injection x. The dashed line shows the level of the iliac crests.

Technique

The adequately premedicated patient is placed on his side with the operative limb uppermost and the thighs flexed on the trunk. The fourth lumbar spine is identified by a line passing through the iliac crests. A

TABLE 1. Analysis of Cases

Operation	Number of Cases	Number of Successes	Number of Failures
Hip nailing	36	33	3
Hip prosthesis	28	27	1
Total hip replacement	3	2	1
Stripping	6	6	0
Patellectomy	9	6	3
Femoral embolectomy	2	2	0
Amputation above knee	3	3	0
Amputation below knee	2	2	0
Femoral plating	2	2	0
Tibial plating	2	2	0
Operation on toes	3	3	0
Extraction of Kuntscher pin	2	0	2
Arteriography	1	1	0
Ankle nailing	1	1	0
<b>TOTAL</b>	<b>100</b>	<b>90</b>	<b>10</b>

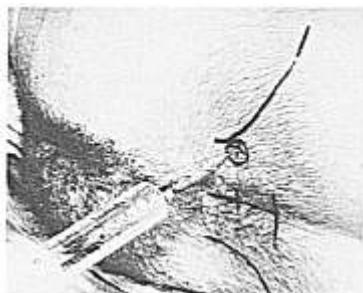


FIG. 5. Injection at point x with the patient lying on his right side.

point 3 cm caudad to this and 5 cm laterally is marked and a wheal is raised on the skin.

A 15-cm 20-gauge needle is inserted through the wheal perpendicular to the skin until it encounters the fifth lumbar transverse process.

The course of the needle is then changed to a slightly cephalad direction until it glides above the transverse process. A 20-ml syringe containing air is then attached to the needle, which is advanced slightly (1-2 cm) to enter the quadratus lumborum. Light tapping on the plunger will elicit resistance when the muscle or the fascia has been entered. The needle is advanced a centimeter at a time until the resistance suddenly disappears. At this stage the point of the needle is in the psoas compartment. The depth of penetration from the skin is usually about 12 cm.

Paresthesias may occur but are not essential. If there is doubt as to the correct placement of the needle it may be advanced still further until it enters the psoas muscle and resistance is once again felt on tapping the plunger. The needle is then withdrawn into the compartment and lack of resistance is again established. Aspiration is performed to ensure that a blood vessel (lumbar vessels) has not been inadvertently entered. Air, 20 ml, is injected to dilate the compartment and then 30 ml of the anesthetic solution selected for the procedure are injected.

The patient is left on his side for at least 5 minutes. Anesthesia is established in the entire thigh except for its sciatic component. If, however, the operative procedure is likely to include the posterior thigh or lower part of the limb a sciatic block should be added. In these cases we have used 25 ml of solution for the psoas compartment block and 15 ml for the sciatic block.

## RESULTS

The method was used to provide anesthesia for 100 orthopedic surgical procedures. It was successful in 90 cases and unsuccessful in ten. Table 1 shows the distribution of the cases according to type of operation and results.

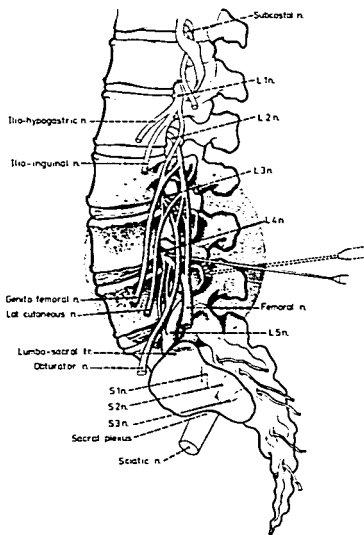


FIG. 6. Schematic. Left lateral view of the lumbar and sacral vertebral columns and corresponding plexuses. The dotted line shows the first course of entry with the needle impinging on the transverse processes of L5. It is then withdrawn and reinserted in a more cephalad direction and is seen with its tip in the psoas compartment at the level of L4.

### Complications

Complications occurred in two cases. In one, anesthetic solution was injected intravascularly, and in the other, inadvertent CSF tap (recognized before injection of material) occurred. Both complications occurred in patients who had gross deformities of the lumbar region.

### DISCUSSION

Nine of our failures occurred in the first 70 cases, while only one occurred in the last 30. The overall failure rate of 10 per cent seems acceptable in view of the fact that a new method was inaugurated and was also taught to colleagues who had no experience of the technique involved. Among the ten procedures in which anesthesia was unsuccessful, two were extractions of Küntschner nails, where the incisions almost certainly impinged on the gluteal distribution of S2. Three were patellectomies, where the lateral sural nerve may have been involved. Anesthesia in these cases would probably have been successful had simultaneous sciatic blocks been performed. The remaining five failures, in operations on the hip, are more difficult to explain. They may have been due to faulty technique, to the use of anesthetic solution more dilute than usually recommended, or to variations in the formation and distribution of the lumbar and sacral plexuses.<sup>1-6</sup>

An acceptable success rate for regional analgesia of the thigh can be obtained by

utilizing the mutual proximity of its nerves in the psoas compartment, with the addition of sciatic block when surgical stimulation of the posterior thigh is indicated. The latter combination will give analgesia of the whole lower limb. The method is reasonably simple to perform and is associated with minimal complications.

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