3. The responsibility for this should be with the surgeon. In the physical field the physiotherapist and occupational therapist can help; in the psychological field a trained field worker (male) who lives with the patients is a necessity. He acts as investigator of individual difficulties, organiser and leader in all group activities.

4. Physiotherapy and occupational therapy have a limited field in Rehabilitation. Repetitive remedial exercises leading to carefully selected industrial therapeutic employment are more important.

5. A scheme of industrial work within the hospital is described, which has given excellent results, and which has largely displaced occupational therapy of the old-fashioned kind.

6. Interim employment in selected factories has been found to be a useful adjunct to this scheme.

BIBLIOGRAPHY

- EMERGENCY MEDICAL SERVICE INSTRUCTIONS.—Preparing sick and injured for return to work. Ministry of Health. *Bull. War Med.*, 1942, **2**, 431-432 (May).
 CAIRNS, H., Rehabilitation after head injuries. *Brit. J. Phys. Med.*, 1942, **5**, 84 (May-June).
 DUKE ELDER, LADY and DAVENPORT, R. C., Rehabilitation in Ophthalmic Cases. *Brit. J. Phys. Med.*, 1942, **5**, p. 88 (May-June).
 GIRDLESTONE, G. R., Occupational therapy for wounded. *Brit. J. Phys. Med.*, 1942, **5**, 91-93 (May-June).
 HOULDING, R. N., Rehabilitation of injured air crews. *Brit. Med. J.*, 1941, **2**, 429-433 (September 27).
 HOWITT, F. D., Rehabilitation and the War. *Brit. J. Phys. Med.*, 1942, **5**, (May-June).
 KESSLER, H. H., Rehabilitation of the physically handicapped. *Sch. Surgeon*, 1940, **9**, 34-40 (January).
 NICOLL, E. A., Rehabilitation of the injured. *Brit. Med. J.*, 1941, **1**, 501-506 (April 5).
 STEWART, D., Rehabilitation of injured workmen, with special reference to Workmen's Compensation Act. *Lancet*, 1939, **1**, 129-132 (January 21).
 TOMLINSON REPORT.—Report on Inter-Departmental Committee on the Rehabilitation and Resettlement of Disabled Persons. January 1943.
 WATSON-JONES, R., Rehabilitation in the Royal Air Force. *Brit. Med. J.*, 1942, **1**, 403-407 (March 28).
 WOODS, R. S., Rehabilitation in the E.M.S. *Brit. Med. J.*, 1942, **2**, 80-90.
 ZIMMER, V. A., Rehabilitation and Workmen's Compensation. *N.Y. St. J. Med.*, 1941, **41**, 1057-1060 (May 15).

ANAESTHESIA FOR ABDOMINAL SURGERY IN ADULTS

By HELEN BOWER ALCOCK, M.R.C.S., L.R.C.P., D.A.

(*Anaesthetist, Soho Hospital for Women; Anaesthetist, French Hospital; Clinical Assistant in Anaesthetics, West London Hospital, etc.*)

The chief methods of anaesthesia available for abdominal surgery in adults are five:—

- (1) Nitrous oxide-oxygen with ether or chloroform.
- (2) Cyclopropane-oxygen.
- (3) Spinal anaesthesia.
- (4) Continuous pentothal sodium-nitrous oxide-oxygen.
- (5) Local anaesthesia.

I propose to refer briefly to the first three. The last two I consider methods of choice, one or other of which is applicable to the majority of cases: they will be dealt with in some detail.

Nitrous oxide-oxygen with ether or chloroform

Chloroform is little used nowadays, but nitrous-oxide-oxygen-ether is still the most popular anaesthetic combination. Its advantages are:

- (1) that complete relaxation of the abdominal muscles is obtainable without having to push the ether unduly, and
- (2) that the signs of anaesthesia are clear and well-defined at the various stages so that for the *infrequent anaesthetist* it is undoubtedly the safest anaesthetic.

Nevertheless its disadvantages are such that every effort should be made to replace it by agents less toxic, less irritant, and attended by less unpleasant sequelae. We are fortunate that recent advances in anaesthesia have provided us with satisfactory alternatives.

Cyclopropane

The introduction of this gas by Waters in 1933 has been of great value in thoracic surgery. In abdominal surgery relaxation is sometimes difficult to attain. Cyclopropane is extremely potent, and therefore can be used with a high percentage of oxygen; thus it is a good supplementary anaesthetic in any condition which requires full oxygenation. For reasons of expense it must be given in closed circuit with carbon-dioxide absorption: the view is now generally held that it is the closed circuit which is, at least in part, responsible for advantages, such as absence of vomiting and shock, which were formerly attributed solely to the cyclopropane anaesthesia.

Spinal Anaesthesia

A spinal anaesthetic should be reserved for long operations on a comparatively fit subject: for such procedures as abdomino-perineal resection of the rectum or Wertheim's hysterectomy it is ideal. In a less fit patient a low spinal may be used to anaesthetise the perineal area while abdominal anaesthesia and relaxation are obtained by means of a rectus sheath block. The patient should not be allowed to remain conscious during the operation unless he desires to do so. The unwillingly conscious patient is liable to suffer a degree of psychic trauma which may materially contribute to the onset of shock. Nitrous oxide-oxygen is sufficient to keep the patient asleep; if available a light cyclopropane-oxygen anaesthesia is, as already noted, excellent.

Continuous pentothal sodium-nitrous oxide-oxygen

The remaining two methods may be considered as complementary to each other. With them, if we possibly except those lengthy operations already mentioned under spinal, it is feasible to produce satisfactory anaesthesia covering the whole field of abdominal surgery. Continuous pentothal sodium-nitrous oxide-oxygen itself has a wider application than is generally supposed. I have used it for such procedures as cholecystectomies; gastro-enterostomies; appendicectomies; colostomies; prostatectomies; supra-pubic cystostomies, repair of inguinal, femoral and ventral herniae; gynaecological abdominal operations, and for acute abdominal emergencies. The patients have been males and females ranging in years from young adults to old age. There have been no cases with any severe intercurrent disease. In one case only have I had complete failure of relaxation: on this occasion I had to switch over to ether. The patient was undergoing salpingostomy, and was therefore in the steep Trendelenburg position; I think perhaps that had I intubated her she would have relaxed. The dosage employed varied from 1 gm. to 2.5 gms. of pentothal though I have only very occasionally used as much as this. The average dose is 1.5 gms.; for short operations such as appendicectomies and herniotomies 1 gm. is sufficient. The patients have all made good recoveries.

Advantages.—Pentothal sodium is pleasant to take—in fact from the patient's point of view it is undoubtedly the ideal anaesthetic. It is neither irritant to the lungs, toxic, nor explosive. Induction is rapid with no struggling, a factor of importance in cases of myocardial degeneration and hypertension. Breathing remains quiet throughout operation, and there is no straining. Post-operative nausea and vomiting are reduced to a minimum.

Importance of Oxygen.—Pentothal causes respiratory depression. It is therefore extremely necessary to maintain a clear airway. In the lighter planes of anaesthesia it is possible to administer nitrous oxide-oxygen to reinforce the pentothal and so reduce its dosage. In the deeper planes the oxygen percentage should be increased, if necessary, to the point of giving 100 per cent oxygen, in order to overcome possible anoxia caused by the shallow breathing. In the normal individual the colour of the lips, lobes of the ears, or the blood from the abdominal wound is an indication of adequate oxygenation. If the administrator is in doubt it is certain that a slight degree of cyanosis is present: this can be verified by increasing the amount of oxygen and noting the change of colour. It is idle to give definite percentages for the gaseous mixture; *it must be adjusted to the patient's requirements and varied throughout the operation.* In anaesthetizing anaemic patients it should be remembered that colour is no guide to the degree of oxygenation, and that a high oxygen percentage is necessary if anoxia is to be avoided.¹ It is impossible to over-emphasise the importance of full oxygenation, particularly in preventing liver damage and post-operative complications. This applies with even greater force in those cases where impaired hepatic function is already present or suspected, and in any case which is classed as a poor anaesthetic risk.²

FIG. 1.—Right Paramedian Incision

FIG. 2.—Midline Sub-Umbilical Incision

FIG. 3.—Inguinal or Femoral Hernia

FIG. 4.—For Appendicectomy

FIG. 5.—Kocher Incision For Cholecystectomy

Contra-indications to pentothal for abdominal Surgery*Absolute*

- (1) Respiratory obstruction.
- (2) Asthma.
- (3) Poor veins.

Relative

- (1) Liver damage.
- (2) Acute abdominal conditions.
- (3) Acute uraemia.
- (4) Septicaemia.
- (5) Long procedures with a slow surgeon.

Cases Requiring Special Care.

- (1) Anaemia.
- (2) Shock.
- (3) Low or high blood pressure.
- (4) Cardiac cases.
- (5) Pulmonary tuberculosis.
- (6) Old age.

With regard to absolute contra-indications it is obvious that the use of pentothal with consequent depression of respiration is unsafe in a patient suffering from respiratory obstruction from any cause. In asthmatics stimulation of the parasympathetic produced by the pentothal may bring on an acute attack; its use should therefore be avoided,³ though many consider it safe to use just sufficient to induce unconsciousness in the patient. Poor veins are another definite contraindication. It is usually possible to find a vein in which to inject a small induction dose; for continuous injection one requires a reasonably good vein. In the case of patients to be operated on in the lateral position the under arm should not be used for injection lest the venous return be partially obstructed by pressure from the overlying body. Should this occur the drug will pool in the veins of the arm with consequent overdose when the circulation is restored.

The use of pentothal in cases of liver or kidney dysfunction is still the subject of controversy, though consensus of modern opinion tends to show that it is not harmful.² I think, except for a small dose to induce anaesthesia, it should be avoided in jaundice; in the seriously ill, acute abdominal emergency; and in uraemia and septicaemia if the alternative of local infiltration plus nitrous oxide-oxygen is available. These are poor risks, and it seems reasonable to give them the least toxic anaesthetic possible. If recourse must be had to pentothal the dosage should be kept as low as possible by making the fullest use of nitrous oxide consistent with *abundant* oxygenation. Speed in operating becomes an important factor in these cases.

Shocked, anaemic or old patients do well with pentothal. For these the dosage must be reduced and the injections made with extra slowness and caution. Shock should, of course, be treated on the usual lines, and operation postponed until a response is obtained. Such patients require a high percentage of oxygen. In hyper- and hypo-tensive patients it is important to avoid as far as possible a fall of blood pressure. Injection should be slow and cautious, particularly during induction. Neglect of this precaution may well be the cause of a fatality. The patient with valvular disease and good compensation constitutes a fair to good risk, and does very well on continuous pentothal with full oxygenation. Poor compensation is a poor risk under any type of anaesthesia; perhaps the best method for these difficult cases is local infiltration plus cyclopropane-oxygen. Pentothal is very satisfactory for patients with pulmonary tuberculosis, provided there is no dyspnoea. If possible, it should be reinforced by cyclopropane-oxygen rather than nitrous oxide-oxygen, thus keeping the oxygen percentage high and the total amount of pentothal low. Long procedures in the hands of a slow surgeon necessitate large doses of pentothal, and may thus constitute a contra-indication. It must be remembered, however, that the type of patient who will require heavy dosage (i.e. the healthy young adult) needs this to settle him at the beginning of the operation, and often takes a surprising amount of the drug before satisfactory anaesthesia is obtained, even for short procedures. Thereafter very little more pentothal is required, so that an extra half-hour or so additional

operating time has little effect on the total dosage. Further, this young robust type of patient is not so liable to chest complications as other groups, and can be allowed a prolonged post-operative sleep with greater impunity.

Premedication

Glucose should be taken freely in the days prior to operation, particularly in cases of suspected liver damage.² Preparations of calcium and vitamin K are useful for jaundiced patients. It is important to see that adequate rest and sedation are secured. Morphia gr. 1/6, atropine sulphate gr. 1/100 are given hypodermically one and a half hours pre-operatively. The latter is extremely valuable as it counteracts the stimulating effect of pentothal on the parasympathetic and so reduces the incidence of hiccup, cough, and laryngeal spasm.⁴

Technique

A 5 per cent solution of pentothal is used throughout. 10 c.c. of this (i.e. 0.5 gm. of pentothal) is drawn up into a 10 c.c. eccentric nozzle syringe and a fine needle size 17-20 attached. 20 c.c. of solution (i.e. 1 gm. of pentothal) is drawn up into a 20 c.c. eccentric nozzle syringe, and a coarse needle, size 12 or larger, attached. The inducing dose of 0.5 gm. (or less in those cases with special indications) is injected before bringing the patient to the theatre. I have found that with an initial dose of less than 0.5 gm. for the average patient there is a tendency to rigidity of the arm, and consequent difficulty over the second injection which is made when the patient is in position for operation. The onset of unconsciousness is marked by the closure of the eyes and a sigh or yawn. The rest of the 0.5 gm. is given slowly, and the patient is wheeled in and lifted on to the table. An airway is inserted and nitrous oxide-oxygen administered from a Boyle's or other machine. An armboard is placed in position, or the arm stretched out over a trolley and a tourniquet applied. A sandbag under the upper arm is usually required for support. The coarse needle with the 20 c.c. syringe attached is now inserted into the vein. The tourniquet is loosened and is used, secured by Spencer Wells forceps, for strapping the syringe in place on the arm. Injection is made as required. If more pentothal is needed the empty syringe is detached and replaced by a full one without removing the needle from the vein. Clotting will not occur if minimal amounts of solution are injected every few minutes.

Once again I would stress the supreme importance in this method of anaesthesia of adjusting the nitrous oxide-oxygen percentages to the patient's requirements: thus in the lighter planes advantage is taken of the nitrous oxide to reinforce the pentothal and so reduce its dosage. In the deeper planes this adjuvant has to be sacrificed, either partially or completely, in order to ensure full oxygenation despite the shallow breathing consequent on deep pentothal anaesthesia.

Local anaesthesia

There is practically no contra-indication to this form of anaesthesia, yet it has never achieved universal popularity in this country. This is probably because the majority of patients prefer to be asleep during operation; and, indeed, the value of the method is in part lost in the case of a conscious patient, in whom psychological trauma becomes a factor to be considered. Ideally, therefore, regional anaesthesia should be combined with a *light* general narcosis, in all cases except—

- (1) Patients who are so ill that they are comatose; this applies especially to the drowsy uraemic patient undergoing supra-pubic cystotomy: such patients once rendered unconscious tend to lapse into coma and death.
- (2) Patients vomiting so continuously that unconsciousness would aggravate the risk of aspiration of vomitus in spite of the presence of a tube in the stomach.
- (3) Patients who particularly desire to remain conscious.

Advantages.

Regional anaesthesia is the method of choice for *all surgically poor risks*, and in such cases presents by far the best chance of "getting away with it." Lundy has said, "I think the hazards associated with this combination (regional plus inhalation) are less than with most other methods."⁵

Disadvantages.

- (1) *Time*.—With practice field blocks can be put in quite speedily, but even so they are always more time consuming than are other means of achieving anaesthesia.
- (2) *Surgical technique*.—Unless a splanchnic block is done there will be protrusion of the abdominal viscera. This can be overcome by efficient packing. A gentle operative technique, always important, is particularly so with this light type of general narcosis. Co-operation between surgeon and anaesthetist is essential. It is useless to attempt to force regional anaesthesia on a surgeon who dislikes it.

Contra-Indications.

Absolute.—Injections should never be made through septic areas or scar tissue. An intercostal block^{6, 7} is a useful alternative in such cases.

Relative.—Enormously obese patients may be difficult to inject. Unfortunately these are the very patients who are likely to have poor veins for continuous pentothal. One way out of the difficulty is for the surgeon, after preliminary infiltration in the line of the proposed incision, to infiltrate the muscles under direct vision after the skin has been cut.

Premedication and Dosage

The principles of premedication do not differ from those already suggested for continuous pentothal. With regard to dosage, for a fit subject I use 2 gms. of procaine hydrochloride B.P. (syn novocaine, planocaine, etc.), made up with 200 c.c. of normal saline into a 1 per cent solution to which is added 0.5 c.c. of 1/1000 adrenaline hydrochloride solution; this should be reduced to 1.5 gm. or 1 gm. in 0.75 per cent or 0.5 per cent solution for very ill, old, or underweight subjects. This dosage is larger than that recommended by Labat⁸ and by Hewer,⁹ who suggest a maximum of 300 c.c. of $\frac{1}{2}$ per cent, 100 c.c. of 1 per cent, and 40 c.c. of 2 per cent solution. I have noticed no ill-effects from the heavier dosage which has the advantage of making relaxation more certain. If there are no contra-indications a preliminary intravenous injection of 0.5 gm. of pentothal given before the block is put in saves the patient the unpleasantness of this procedure and helps to counteract any toxic effect of the procaine. If pentothal is contra-indicated the block can be done under nitrous oxide-oxygen anaesthesia.

Technique

The patient, anaesthetised by an intravenous injection of 0.5 gm. of pentothal, is put on the table, an airway is inserted, and nitrous oxide-oxygen administered from a Boyle's machine, the mask being strapped to the face by a harness. If there is any obstruction to respiration an attendant must hold the jaw forward, but usually if the head is turned to one side breathing is free. The anaesthetist proceeds to scrub up, meantime keeping watch on the patient's respiration by observing the filling and emptying of the re-breathing bag on the machine. The abdomen is swabbed with spirit, painted with iodine, and draped with sterile towels. The injections are then begun, the materials having been previously prepared on a sterile tray.

Many techniques for local anaesthesia have been described—I have found the following methods satisfactory: they are easy to acquire, fairly speedy, and no moving or turning of the patient is involved. I have always achieved good relaxation with lower rectus sheath blocks; upper abdominal blocks are not so completely certain owing to possible pull from the oblique abdominal muscles. Splanchnic block is of value in difficult cases where much handling of the viscera is necessary; it can either be put in by the surgeon after he had opened the peritoneum (Braun's method)⁵; or by the anaesthetist, using the posterior approach of Kappis,⁷ before the operation is started.

Field block for upper abdomen (right or left paramedian incision), Fig. 1.—Make 5 injections of 15 c.c. of analgesic solution into the outer border of the rectus sheath on the side of the incision so spaced that they are placed more closely in the upper than in the lower abdomen. This gives better relaxation than merely infiltrating opposite the incision. Care must be taken that at least one injection goes into the space between each tendinous intersection of the rectus, as these bar the spread of the fluid. This uses 75 c.c. of the solution.

Make 1 injection of 15 c.c. of analgesic solution into the muscle substance just below the xiphisternum.

Make 4 injections of 15 c.c. of analgesic solution into the outer border of the rectus sheath on the side away from the incision so spaced that they are placed more closely in the upper than in the lower abdomen. This uses another 60 c.c.

Use the rest of the solution, i.e. 50 c.c., for subcutaneous infiltration in the line of the proposed incision.

Field block for lower abdomen (mid-line sub-umbilical incision), Fig. 2.—Make 5 injections of 15 c.c. of analgesic solution into the outer border of the rectus sheath of both sides, so spaced that they are placed more closely in the lower abdomen than in the upper (= 150 c.c.).

Use the rest of the solution for subcutaneous infiltration along the line of the proposed incision (= 50 c.c.).

For suprapubic cystotomy of the remaining 50 c.c. use 10 c.c. for injection into the cave of Retzius behind the symphysis pubis, and the rest (40 c.c.) for the subcutaneous infiltration.

Field block for hernia (inguinal or femoral), Fig. 3.—Take a point 4 cms. internal to the anterior superior iliac spine on the side affected. From this make 4 fanwise injections of 15 c.c. of analgesic solution between the muscle layers (= 60 c.c.).

From the same point do a subfascial injection down to the symphysis pubis (= 20 c.c.).

Repeat in the subcutaneous plane (1), Fig. 3 (= 20 c.c.).

From the same point make a subcutaneous injection running down distal to the hernia (2), Fig. 3 (= 20 c.c.).

Join the last 2 subcutaneous injections so that the hernia is now enclosed (3), Fig. 3 (= 20 c.c.).

Define the external abdominal ring. Take the unattached needle and pass it 6 cms. up the inguinal canal, pointing upwards and outwards, running along the roof. Connect the syringe. Inject 20 c.c. Thus the total solution used is 160 c.c.

Field block for appendectomy, Fig. 4.—Take a point 4 cms. internal to the right anterior superior iliac spine. From it make 4 fanwise injections of 15 c.c. of analgesic solution between the muscle layers (= 60 c.c.).

Take a point in the same line level with the umbilicus and inject 15 c.c. between the muscle layers (= 15 c.c.).

Take 3 points along the outer border of the right rectus sheath—

(1) just above the umbilicus,

(2) just above the symphysis pubis, and

(3) midway between these points and inject 15 c.c. at each into the sheath (= 45 c.c.).

Make subcutaneous injections joining these points (= 80 c.c.).

The total solution used is 200 c.c.

Field block for Kocher incision for cholecystectomy, Fig. 5.—Make 5 injections of 20 c.c. analgesic solution into the muscle layers below the costal margin, proceeding from the xiphisternum outwards (= 100 c.c.).

Make a subcutaneous infiltration in the line of the incision below the right costal margin (= 50 c.c.).

Make a subcutaneous infiltration in the midline to prevent overlap (= 50 c.c.).

The total solution used is 200 c.c.

Finally, the exact technique of making the injections: for infiltration of the muscles the unattached needle should be used in the first instance. It is inserted through the skin at an angle of 45°, after which it advances easily through the subcutaneous fat until it comes up against the resistance of the muscles. It is now given a sharp push so that the point enters the muscle substance, advancing about a further $\frac{1}{2}$ of an inch. Its location is easy to recognise, as one can feel it gripped by the muscle. The syringe is attached, and the whole depressed to an angle of about 5° before injecting a small amount of solution to clear the needle. Aspiration is now attempted. If blood enters the syringe the needle is in a vessel and must be withdrawn and inserted elsewhere. If bubbles enter the syringe the needle has pierced a loop of bowel and must be withdrawn and discarded. Accidental piercing of the peritoneum without entering gut is of no importance save that analgesic fluid is wasted with consequent possibility of failure of the block. If the aspiration test is negative injection is completed. It is obvious that it is exceedingly important never to omit this test. For the subcutaneous infiltration the needle

with the syringe attached is pushed along under the skin for almost its full extent. Injection is made as the needle is withdrawn, the point being directed upwards so that it can be seen running along beneath the skin. *In this way injection into vessels is avoided.

Summary

The various types of anaesthesia for abdominal surgery are discussed. It is suggested that the most satisfactory methods are continuous pentothal nitrous oxide-oxygen or field block nitrous oxide-oxygen. The value of the latter method in all poor risk cases and in cases where pentothal is contra-indicated is stressed. The techniques for the two methods are described.

I wish to express my thanks to Dr. Rotha Barnfield for the diagrams and to Dr. John Beard and Dr. Geoffrey Organe for much helpful criticism.

REFERENCES.

1. CHASE, H. C. (1941), *Surg. Gynae. Obst. Int. Abstract*, **73**, 105.
2. LUNDY, J. S., TUOHY, E. B., ADAMS, R. C., MOUSEL, L. H. (1941), *Proc. Staff Mtgs. Mayo Clinic*, **16**, 5.
3. TUOHY, E. B. (1937), *Anaesth. and Analg.*, **16**, 164.
4. LONG, C. H., and OSCHNER, A. (1942), *Surgery*, **11**, 474.
5. LUNDY, J. S. (1940), *Journ. Amer. Med. Assoc.*, **115** (ii), 1693 (Discussion).
6. JAMES, N. R., and BURGE, H. W. (1941), *Brit. Med. Journ.*, **2**, 906.
7. BARTLETT, R. W. (1940), *Surg. Gynae. Obst.*, **71**, 194.
8. LABAT, G. (1922), *Regional Anaesthesia*, 42.
9. HEWER, C. L. (1943), *Recent Advances Anaesth. and Analg.*, 150.
10. FINSTERER, H. (1932), *Brit. Med. Journ.*, **2**, 399.

GRAVITY CONTROL IN SPINAL ANAESTHESIA

By WILLIAM MUSHIN, M.B., B.S., D.A.

(From the Nuffield Department of Anaesthetics, Oxford)

Lumbar puncture for spinal anaesthesia is performed in the third, or fourth lumbar interspace because at these levels there is no danger of injury to the spinal cord, and the disposition of the spinous processes facilitate the passage of the needle. The problem confronting the anaesthetist after introducing his drug is to make it come into contact with the anterior and posterior roots supplying the area in which anaesthesia is desired. "Volumetric displacement" and "gravity control" are the means used to bring about this movement of the anaesthetic drug.

The volume factor

By the first is meant the displacement of cerebrospinal fluid by another fluid, containing the anaesthetic drug. By virtue of its volume alone, a solution injected intrathecally will affect a certain number of segments, since "diffusion" of one liquid into another of different composition takes place slowly in the absence of turbulence. Some idea of the levels that

FIG. 1.—Curves of spine and estimated volume of C.S.F. at various levels.