MODERN TRENDS IN SPINAL ANAESTHESIA*

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THIS PAPER dealing with modern trends or current concepts of spinal anaesthesia is based upon an extensive review of the old and the recent anaesthesia literature, discussions with anaesthesiologists as well as surgeons, and the experiences gained in a private series which exceeds 21,000 consecutive spinal anaesthetics. Despite the introduction of new and excellent inhalation anaesthetic agents and the advent of muscle relaxants, it is generally agreed that there is a need for spinal anaesthesia today, although isolated statements to the contrary have appeared.[1-7]

A largely unjustified resentment of spinal anaesthesia by patient and physician alike has gradually appeared during the past decade because of adverse publicity in the lay press and the medical literature. This, combined with superstition and lack of understanding, has decreased the number of spinal anaesthetics administered, particularly in some localities. In many instances technical incompetence on the part of the anaesthesiologist is probably responsible for the infrequent use of spinal anaesthesia. In our opinion this method of conduction anaesthesia is in many circumstances the safest and most satisfying method of anaesthesia available today, providing its physiological effects and its limitations are fully understood.[1,3,6]

Most of our concepts of the potential hazards or complications of spinal anaesthesia are based upon articles written twenty to thirty years ago which are still being used as references and are consequently believed by some to apply to present-day spinal anaesthesia.[7-10] The articles which state that a marked increase in white blood cells and proteins in the cerebrospinal fluid occurs routinely following spinal anaesthesia were written when this form of anaesthesia was frequently followed by various inflammatory or neurolytic reactions which were due to the following factors among others: toxic local anaesthetic agents, inadequately sterilized or contaminated equipment and agents, traumatic needles and hazardous techniques of administration.[10] Blood introduced in the subarachnoid space by traumatic spinal taps, although relatively harmless, may also produce signs of meningeal irritation. It is significant that changes in the spinal fluid protein or cell counts do not follow uneventful spinal anaesthesia conducted with modern techniques, and it has furthermore been shown that changes or fluctuations in total protein, albumin, and globulin which develop following

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uneventful spinal anaesthesia appear to be directly related or secondary to similar changes in the blood.[11]

During the past 15 years or so an increasing number of articles have appeared which point out that spinal anaesthesia is exceedingly safe and postoperative complications are minimal when it is correctly administered and supervised.[1-4,12-15] A typical example is "A Defense of Spinal Anesthesia" by Frank Cole, published in 1952.[7] Table I presents a summary of 20 scientific publications

TABLE I

REPORTS ON SPINAL ANAESTHESIA: SUMMARY OF LARGER SERIES ONLY*

Authors	Year of publication	Number of cases
Dripps and Vandam	1954	10,098
Sadove and Levin	1961	20,000
Bonica	1953	12,000
Moore and Bridenbaugh	1966	11,574
Macer	1956	34,936
Black	1965	5,338
Ebner	1959	21,545
El-Sherbiny *et al.*	1966	20,000
Hebert *et al.*	1950	5,763
Jackson and Petch	1955	10,350
Romberger and Ratcliff	1948	10,000
Scarborough	1958	5,000
Rogers	1948	5,000
Stein and Tovell	1935	10,000
Lund and Cwik	1967	21,000
Various series over 2000	1947–1965	16,589
Total		219,193

*No incidence of permanent motor paralysis reported.

dealing with relatively large series of spinal anaesthetics, the combined total of which exceeds 200,000 cases, in which there were no prolonged severe neurological sequelae secondary to the method of anaesthesia.[1,2,4,12,14,16-33] The series reported by Dripps and Vandam was scrutinized particularly closely; the authors simply concluded that major neurological damage need not follow spinal anaesthesia.[1] Sadove and Levin arrived at the same conclusion but encountered three cases of meningitis, two of which survived without sequelae.[12] In our series, which exceeded 21,000 spinal anaesthetics, no major neurological sequelae were encountered which could not logically be attributed to another cause such as metastatic carcinoma of the spine, viral infections, or pre-existing neurological diseases.[26] It is also interesting to note that many of the authors of the above series not only report an absence of an operating room fatality but also state that no deaths were due to the spinal anaesthetic. Many other articles, such as those by Arnes,[34] Thorsen,[35] and Everberg,[36] have also been published which report a very low incidence of severe neurological sequelae or deaths due to spinal anaesthesia. Arnes surveyed the results of 21,230 spinal anaesthetics performed in the Karolinska Institute, Stockholm, and found complications to be extremely

rare.[34] Everberg, who conducted a survey regarding the after-effects of anaesthesia, encountered approximately as many postoperative complaints following intravenous anaesthesia as following spinal anaesthesia.[36] He thus concluded that a majority of complaints are related to the patients' physical condition and/or the surgical procedure rather than to the anaesthesia.

Keown stated in 1959 that many more patients, as well as physicians, would prefer spinal anaesthesia if they knew about its relative freedom from complications.[3] Despite the misgivings regarding spinal anaesthesia, there is a general underestimation of the number of spinal anaesthetics actually administered throughout the world, primarily because of a reluctance to present scientific papers dealing with a subject which is neither new nor considered interesting by a majority of anaesthesiologists. A compilation of the total number of vials or ampules of local anaesthetic agents prepared exclusively for spinal anaesthesia by American pharmaceutical firms for domestic use indicates that approximately 3 million spinal anaesthetics were administered within the continental United States in 1964 and a greater number was predicted for 1965.[37] This suggests that many anaesthesiologists have a keen desire to maintain their patients' physiological states as near normal as possible despite local customs and potential hazards of law suits. Saddle block anaesthesia in obstetrics probably accounts for a considerable percentage of the spinal anaesthetics administered.[17–19,24,30–33,38–42]

Patient acceptance of spinal anaesthesia has also been enhanced by the amnesia and tranquility induced by adequate preoperative medication in line with present-day concepts, as well as the introduction of balanced or light supplemental anaesthesia which renders the patient unconscious prior to and/or during the operative intervention.[43] It is readily apparent that most anaesthesiologists primarily employ one method or technique of administering spinal anaesthesia in every instance and consequently tend to have a rather myopic view of this form of conduction anaesthesia. This situation is in a large measure responsible for the dogmatic statements made by responsible anaesthesiologists, particularly in regard to the indications and contraindications of spinal anaesthesia. It is now apparent that there are many types of spinal anaesthesia, some of which are listed in Table II.[10,44–46] The choice of agents as well as the technique of administration of spinal anaesthesia should therefore depend upon the circumstances at hand rather than upon habit. It is not surprising, for example, that those who always utilize a hyperbaric technique find spinal anaesthesia unsatisfactory for various renal or ureteral procedures. Spinal anaesthesia induced with a small dose of hypobaric pontocaine, which makes it possible to keep the patient's head below horizontal at all times and actually increases cardiac output because of improved venous return to the heart, may well be the anaesthetic method of choice for an operation upon the lower limb of a bleeding or poor risk patient, whereas, spinal anaesthesia induced with hyperbaric pontocaine, which requires the head and shoulders to be elevated, is definitely contraindicated.[46,47] It is therefore obvious that it is desirable to be able to administer all types of spinal anaesthesia including hemianalgesia.

TABLE II

VARIABLE METHODS OR TECHNIQUES OF SPINAL ANAESTHESIA

1.	Specific agents (crystals, solution)	Procaine Tetracaine Dibucaine Lidocaine
2.	Diluents	spinal fluid normal saline distilled water
3.	Supplementary or complementary agents	vasoconstrictors glucose
4.	Proprietary preparations	Jones solution Pontocaine and glucose
5.	Various combinations of above	
6.	Single-dose or continuous methods	
7.	Specific techniques low, medium, high segmental levels	Etherington-Wilson Sise saddle

PHYSIOLOGY

The essential physiological effects of spinal anaesthesia are briefly summarized in Table III. It has been well established that these effects are primarily secondary to preganglionic sympathetic blockade which produces hypotension by reducing venous return; the extent of reduction varies directly with the segmental level of blockade.[47] The decrease in pulse rate during high spinal anaesthesia is primarily due to decreased pressure in the large veins and the right side of the heart rather than to a blockade of the cardiac accelerator nerves. The decrease in flow in normal coronary arteries which follows a lowering of

TABLE III

PHYSIOLOGY OF SPINAL ANAESTHESIA

Condition	Result	Produced by
Sympathetic blockade	hypotension	arterial and arteriolar vasodilatation decrease in blood pressure and peripheral resistance loss of venous tone, venous pooling reduced venous return, reduced cardiac output
Bradycardia		decreased blood pressure in right auricle and great veins blocked cardiac accelerator nerves
Myocardial work	decreased	
Coronary blood flow	unchanged	
Pulmonary ventilation	unchanged	
Compensatory vasoconstriction above block		
Catecholamine levels	no increase	

the mean aortic blood pressure is more than compensated for by the decrease in myocardial work due to the lower peripheral resistance, decreased cardiac output, and bradycardia. A significant decrease in coronary blood flow may, however, follow severe hypotension or occur in the presence of abnormal coronary arteries. Every patient in whom high spinal anaesthesia has been induced with or without concurrent hypotension should be placed in the head-down position, since adequate venous return and cardiac output cannot be maintained in any other position under such circumstances. It has been frequently shown that pulmonary ventilation remains practically unchanged in the presence of high spinal anaesthesia accompanied by intercostal paralysis, and the flaccid abdominal muscles and the contracted bowel permit greater diaphragmatic excursion.[47,48] Thus spinal anaesthesia, regardless of its level, has no significant effects on the arterial oxygen content, capacity, or saturation.[47,49] The primary cause of ventilatory insufficiency during spinal anaesthesia is interference with diaphragmatic excursion by intra-abdominal sponges, packs, or retractors, or faulty positioning. Rarely it may be due to paralysis of the phrenic nerve or to central respiratory failure. The absence of an increase in catecholamines during spinal anaesthesia also suggests an inherent safety factor which is not present with inhalation or intravenous anaesthesia.[47]

Local Anaesthetic Agents

It is apparent that only a relatively small number of spinal anaesthetic agents are used to any appreciable extent today. These include tetracaine, procaine, lidocaine, dibucaine, and mepivacaine, but other new agents, such as propitocaine, which combines a low systemic toxicity with a prolonged duration of action, show great promise.[50,51] Each local anaesthetic agent has its own characteristic duration of action which may be enhanced by the addition of glucose or various vasoconstrictor agents. Detoxification of these agents primarily occurs following removal from the subarachnoid space by vascular absorption, and therefore the duration of anaesthesia is increased by any factor which decreases blood flow, such as senility, arteriosclerosis, or prolonged hypotension.[47] Fortunately only a very small number of patients are sensitive to these local anaesthetic agents and, contrary to popular opinion, there is no satisfactory test for sensitivity to a particular local anaesthetic agent other than by clinical administration.[52] The dose of these agents required for spinal anaesthesia is also so small that manifestations of systemic toxicity rarely if ever occur unless the drug has been administered intravenously. Since many of the complications of spinal anaesthesia which occurred in the past were due to the administration of excessive concentrations and/or dosages of toxic local anaesthetic agents either singly or in combination, with or without various neurotoxic or neurolytic additives, there is now a tendency to employ the currently popular anaesthetic agents in various dilute solutions as well as in minimum dosage.[53] The total dose of local anaesthetic agent required has also been decreased by supplementation with light inhalation or intravenous anaesthesia.

Techniques

A vast majority of anaesthetists prefer a simple technique consisting of the administration of one drug by the single-dose method. It is equally apparent that most employ convection by gravity to determine the spread of the local anaesthetic agent within the subarachnoid space. The hyperbaric technique, which depends upon the addition of glucose to increase the specific gravity of the local anaesthetic agent to at least 1.011, appears to be utilized more extensively than any other technique.[1,2,4,12,18,20,23] Isobaric techniques which depend upon the concentration as well as the volume of local anaesthetic agent administered are generally not popular. Hypobaric dibucaine (Nupercaine) is rarely used, but an increasing number of spinal anaesthetics are conducted with the hypobaric tetracaine (Pontocaine) technique. An anaesthetic solution with a specific gravity of less than 1.003 is prepared by adding 20 c.c. of distilled water to 20 mg. of tetracaine crystals (Niphanoid).[46] Dispersion of the local anaesthetic agent by barbotage is impossible to control accurately, and Jonnesco's technique of varying the level of injection is too hazardous; thus these two methods of controlling the segmental spread of analgesia are probably no longer used.[40,45,54]

It is generally agreed that an intravenous infusion should be running during spinal anaesthesia, but considerable controversy exists regarding the use of vasopressors. I believe that a majority of anaesthetists prefer administering vasopressors in the local wheal at the site of puncture, while others only administer these agents if necessary to control a hypotensive episode.[10,16,41,45] It has, however, been well established that those agents which increase cardiac output by increasing venous return are generally preferable to those which elevate the blood pressure by increasing peripheral resistance and consequently the work load of the heart.

Continuous Spinal Anaesthesia

There has been a marked decrease in the use of continuous spinal anaesthesia during the past decade because of the relatively large number of complications which followed the original techniques of Lemon and Tuohy.[55–57] The insertion of a fine polyethylene catheter which can be sterilized by autoclaving and passed through an 18-gauge thin-wall Tuohy needle is, however, considered a satisfactory and safe technique by many anaesthesiologists.[1,14,45] We have employed this technique in a large number of cases including prolonged periods for five days or more without encountering irreversible neurological sequelae or infection.[58] The continuous technique makes it possible to induce prolonged limited segmental analgesia by the administration of repeated small doses of dilute nontoxic and short-acting local anaesthetic agents. The advantages of this type of controllability are obvious, but this technique is accompanied by a considerable number of potential hazards over and above an increased incidence of headaches, and therefore some anaesthesiologists feel that it is rarely if ever indicated.

Hypobaric Tetracaine (Pontocaine)

There are an increasing number of reports dealing with the use of dilute solutions of local anaesthetic agents such as hypobaric tetracaine (Pontocaine), which we introduced in 1945.[45,46,59-62] The main advantages of this method have been presented previously[46] and are outlined in Table IV. The technique, which is conducted with a freshly prepared 0.1 per cent solution of tetracaine, is suitable for all operative procedures in which spinal anaesthesia is indicated, but it is used primarily for various positional procedures such as renal, rectal, and lower spinal or vertebral column operations.

TABLE IV

ADVANTAGES OF HYPOBARIC PONTOCAINE SPINAL ANAESTHESIA

1.	Trendelenburg position possible throughout	promotes venous return, prevents cerebral anoxia
2.	Facilitates postural operative procedures	minimal manupulation—renal, rectal, spinal, etc.
3.	Accurate control of segmental spread	markedly hypobaric—convection by gravity
4.	Short latency, prolonged duration, minimal toxicity	
5.	Differential nerve block	sensory blockade 2–4 segments higher than motor
6.	Absence of neurological sequelae	

Vasoconstrictor Agents

Following the suggestion that constriction of the nutrient arteries to the spinal cord, which are few in number, might produce hypoxia followed by neurological complications,[14,63-65] there has been a decrease in the incidence of intrathecal administration of vasoconstrictor agents to prolong the duration of action of local anaesthetic agents. There is no proof of this suspicion; furthermore it has been demonstrated in monkeys that excessive concentrations must be administered for prolonged periods of time to do any harm at all.[66] Clinically it has also been demonstrated in large series of cases that the intrathecal administration of vasoconstrictors is not followed by an increase in neurological sequelae.[1,11,14,63,66] The controversy regarding the relative effectiveness of these agents as potentiators of spinal anaesthesia has been due to a failure to use standardized dosages. It has been conclusively demonstrated that phenylephrine is the most effective, followed by epinephrine, and that ephedrine has little effect if any in prolonging spinal anaesthesia.[14,64] It has also been demonstrated that glucose itself causes a prolongation of spinal anaesthesia.[67] It thus appears that the fear of using vasoconstrictor agents to prolong the duration of spinal anaesthesia is unjustified.

Induction Methods

It is increasingly evident that more interest is being shown in the various needle approaches to the subarachnoid space, each of which have specific advantages not inherent in the standard midline approach. Such advantages are: avoidance of an overhanging spinous process, production of smaller dural punc-

tures, increased patient comfort, facilitation of spinal puncture in the presence of arthritis or abnormal spinal curves, and abolishment of the need for flexion of the patient's back. The needle approaches are illustrated in Table V.

TABLE V

METHODS OF INDUCING SPINAL ANAESTHESIA

Approach	Position
Standard mid-line	parallel to spinous processes
Lateral (Maxson)	2 cm. lat. and 2 cm. post. to centre
Taylor	1 cm. caudal and medial P.S.I.S.; 55° cephalad and medial—L_5–S_1
Modified Taylor	1 cm. cephalad and medial P.S.I.S.; 45° cephalad—L_4 or L_5
Unflexed back	neutral position (mid-line or lateral, single or continuous)

Unilateral Spinal Anaesthesia (Hemianalgesia)

Unilateral spinal anaesthesia is not employed to any appreciable extent because it is time consuming and only applicable at the lower segmental levels. It is, however, preferable to conventional spinal anaesthesia in poor-risk patients for surgery of the inguinal region, hip, or lower extremity.[45,68]

Spinal Needles

It is now generally conceded that the shape of the point as well as the gauge of the needle is significant in reducing the incidence of post-spinal headaches, backaches, and paraesthesiae. An increasing number of anaesthesiologists therefore use 21 or 22 gauge needles for general surgery and the 24 to 26 gauge needle for obstetrics. The pencil point needles and those with rounded rather than cutting bevels make smaller holes in the dura; short bevelled needles tend to punch out relatively large holes in the dura, while the long bevelled needles are accompanied by an increased incidence of paraesthesiae, subarachnoid haemorrhage, and a higher failure rate.[45,69,70]

SUITABLE OPERATIVE PROCEDURES

It is generally agreed that spinal anaesthesia is particularly indicated for surgical procedures requiring segmental levels of analgesia below T8 or T9 as well as for vaginal deliveries and caesarean sections. There are, however, numerous surgeons who prefer spinal anaesthesia for operations below the level of the diaphragm because the degree of relaxation required cannot be achieved with general anaesthesia together with muscle relaxants without concomitant depression of respiratory and circulatory function. In addition, as shown in Table VI, spinal anaesthesia may also be indicated in special situations, or because of the physical condition of the patient.[1,43,45,47] Appropriate situations include the following.

TABLE VI

SPECIAL INDICATIONS FOR SPINAL ANAESTHESIA

Particularly suitable operative procedures
1. lower abdomen, pelvis, and legs
2. anorectal and lower spine
3. obstetrics and caesarean section
Miscellaneous conditions or situations
1. geriatric patients
2. pulmonary emphysema
3. obesity
4. pulmonary oedema
5. phobias

Geriatric patients. Spinal anaesthesia causes the least interference with the functions of the human organism, particularly if surgery is confined to operations below the tenth thoracic dermatome. However, many do not hesitate to use spinal anaesthesia for surgical procedures in the upper abdomen in selected cases.[71] We have previously pointed out that the hazards imposed by the effects of senescence may more than offset the advantages normally inherent in peridural anaesthesia.[5]

Pulmonary emphysema. Spinal anaesthesia is desirable in these patients because tidal volume is not decreased. Conduction anaesthesia, including spinal anaesthesia, should probably always be considered for patients with chronic pulmonary emphysema, especially in those with cardiac insufficiency, providing adequate coronary circulation can be maintained.

Obesity. The duration as well as the hazards of the recovery period are markedly reduced by the use of spinal rather than general anaesthesia.

Phobias. Spinal anaesthesia may well be the method of choice in patients who are afraid to go to sleep.

PREOPERATIVE PREPARATION AND EVALUATION

There is general agreement that the physiological and psychological preparation of the patient is of particular importance if the surgical procedure is to be conducted with spinal anaesthesia, and the patient may be expected to remain conscious not only during an induction of the analgesia but also throughout the surgical intervention. Adequate preoperative evaluation, medication, and preparation of the patient is therefore considered as an integral part of spinal anaesthesia.

It is a matter of individual clinical judgment whether or not spinal anaesthesia is indicated for a specific operative procedure. It is essential to assess the patient's cardiovascular status carefully, particularly if spinal anaesthesia is to be accompanied by extensive sympathetic blockade with the consequent hazards of hypotension. There is general agreement that patients with fixed cardiac output combined with reduced peripheral vascular compensatory powers secondary to generalized arteriosclerosis and/or stenotic valvular lesions cannot

safely tolerate hypotensive episodes because relative hypertension may be necessary for adequate tissue oxygenation. Similarly, most authorities feel that extensive sympathetic blockade is contraindicated in patients with hypovolaemia or electrolyte imbalance, or in those who for any reason may be considered poor risks. In geriatric patients the most important consideration is the physiopathological changes in the heart, blood vessels, brain, kidney, and other organs, which render these patients particularly vulnerable to the harmful effects of pronounced hypotension and impaired respiratory function.

In many of the above situations, however, we have found that the judicious use of small doses of vasopressors and proper positioning makes it possible to maintain the patient's blood pressure and circulation within normal limits and thereby prevent the various disadvantages of inhalation anaesthesia. Patients under 30 years of age are known to be able to compensate sufficiently to maintain blood pressure within normal limits even with segmental levels of spinal anaesthesia extending to T5 or higher, but elderly patients, especially those with marked arteriosclerosis, are known to be prone to develop moderate or severe hypotension, even with relatively low segmental levels or blockade. Coronary artery disease itself is no contraindication to spinal anaesthesia. Cardiac symptoms or a history of angina pectoris, although they increase the risk, should also not be considered *per se* as being contraindications to spinal anaesthesia. It is also important to ascertain prior to spinal anaesthesia whether or not the patient has received prolonged therapy with tranquillizers, rauwolfia preparations, or adrenocortical steroids, in order that special precautions may be taken and appropriate medication administered.

Complications

Minor Complications

The incidence of minor complications such as nausea and vomiting during spinal anaesthesia has been greatly decreased by adequate preoperative medication as well as by appropriate supplementation during the operative intervention. The incidence of backache is extremely low following modern atraumatic techniques, and urinary retention depends more upon the operative procedure than the method of anaesthesia.

Post-spinal Headache

This is the most vexing problem of spinal anaesthesia but it has been markedly reduced by adequate hydration, improved needles, aseptic techniques, special positioning, psychotherapy, and patient selection.[14] The incidence of post-spinal headache which was previously reported to occur in 5 to 15 per cent of patients has more recently been reduced to 5 per cent or less.[12,69,70,72,73] Moore, for example, reports an incidence of less than 2 per cent in a carefully documented series.[14] The headache is due to decreased intracranial pressure secondary to leakage of spinal fluid and in less than 1 per cent of cases it may be accompanied by temporary visual and auditory symptoms.[1,69] The incidence of cranial nerve

palsies appears to vary directly with the extent of dural trauma, occurring more frequently following continuous spinal anaesthesia conducted with large ureteral catheters. Adequate therapy of post-dural-puncture cephalgia is a most important factor in their prevention.

The incidence of headache is greatest in the younger age groups, in the presence of endocrine imbalances such as occur in the menopause, and following rectal surgery and vaginal delivery. Therefore many prefer peridural anaesthesia for these procedures.[14,69] In any event the incidence as well as the severity of post-spinal headaches, which have been greatly reduced by modern techniques, are also to a large extent controllable and need not be a deterrent to the use of spinal anaesthesia. The treatment of these headaches consists of rest in bed in the supine position, analgesics, adequate hydration, various pet remedies, tight abdominal binders if post-delivery and peridural or subarachnoid injection of normal saline if necessary.[1,14,69]

Total Spinal Anaesthesia

Total spinal anaesthesia is an exceedingly rare preventable complication which is due to gross overdosage of the local anaesthetic agent and/or carelessness in the management of the patient. Apnoea is usually due to medullary depression secondary to hypoxia and poor tissue perfusion rather than to high blockade of motor nerves. Adequate therapy of the circulatory and respiratory depression should prevent a fatal outcome in every instance.[69] Similarly, excessively high spinal anaesthesia, which occasionally occurs even in expert hands, should in most instances not unduly jeopardize the life or welfare of the patient.

Major Neurological Complications

It is still uncertain whether complications affecting the meninges are due to the concentration of the local anaesthetic agent or to an irritative action of a detergent or other neurotoxic compound.[74,77] There is little doubt that most of the cases of adhesive arachnoiditis and paraplegia which have been attributed to spinal anaesthesia were due to various errors in its administration. This has been demonstrated conclusively by investigative work in animals.[1,14,69]

It is also now apparent that many temporary and permanent neurological complications which were attributed to spinal anaesthesia actually were due to pre-existing neurological disease, cerebrovascular accidents, trauma to peripheral nerves, acute infectious neuronitis, toxic plexites, disuse atrophy, vertebral disease, trauma to radicular arteries, hysteria, and numerous other causes.[1,14,69,78,79] The true cause of a postoperative neurological complication can usually be determined by careful neurological examination and by electromyography. In a study of 482 patients, for example, in which various neurological complaints seemed to be related to spinal anaesthesia, it was shown by the electromyograph that they were really related in only four of the cases.[80]

However, it cannot be denied that isolated reports of major neurological sequelae do occur from time to time; but their incidence is probably lower than the rate of deaths due to inhalation techniques. There is also little doubt that a majority of such complications are preventable, being due to errors in technique.

Cognizance must also be taken of the fact that not all spinal anaesthetics are given by experts in this field and a few, for example, still recommend that the anaesthetic agents be soaked in coloured antiseptic solutions. Overconfidence in applying what appears to be a simple and easy technique may also have disastrous consequences. It is well known that arachnoiditis and paraplegia have been found in patients who have not been subjected to a spinal tap or spinal anaesthesia, and these sequelae have also occurred postoperatively following general or inhalation anaesthesia. The cause in these cases is unknown.

Deaths

Deaths during spinal anaesthesia have become an exceedingly rare occurrence and many reports dealing with large series state that no fatalities occurred on the operating room table. The great majority of deaths which have occurred either during or following spinal anaesthesia have, however, been directly related to the patient's systemic condition,[1,4] and the recent American literature indicates that the incidence of death is greater following general than following spinal anaesthesia. Historically, death occurred due to the effects of hypotension and respiratory depression, but modern preventive and supportive therapy has almost completely eliminated these hazards as a threat to life, at least in the presence of a vigilant anaesthesiologist.

Prevention of Complications

It is generally agreed that most complications of spinal anaesthesia can be prevented by: (*a*) carefully selecting adequately premedicated patients, with particular emphasis being placed upon the hazards imposed by senility, arteriosclerosis, and hypertension, (*b*) avoiding the use of spinal anaesthesia in the presence of any contraindications, (*c*) using an acceptable and proven technique, (*d*) administering accepted local anaesthetic agents only, (*e*) avoiding the use of continuous spinal anaesthesia whenever possible.

Indications

It is apparent that there are very few absolute indications for spinal anaesthesia. This is particularly the case since the advent of peridural analgesia. It is also generally accepted that spinal anaesthesia is only indicated under the following circumstances: (*a*) an absence of any contraindication, (*b*) an anaesthesiologist who is adequately trained in all aspects of this method of conduction anaesthesia, (*c*) satisfactory equipment and acceptable anaesthetic agents adequately sterilized, (*d*) a suitable operative procedure, and (*e*) preferably, a co-operative surgeon.[45]

Contraindications

Spinal anaesthesia is generally contraindicated in the absence of any of the indications as well as in the presence of certain physical factors listed in Table VII. There is universal agreement regarding the absolute contraindications, but some controversy regarding the relative contraindications.

TABLE VII

CONTRAINDICATIONS FOR SPINAL ANAESTHESIA

Absolute
1. local infection of skin (septicaemia, bacteraemia)
2. severe haemorrhage or shock
3. diseases of the central nervous system
4. sensitivity to anaesthetic agent
Relative
1. specific preanaesthetic medication (loss of vasomotor control)
2. technical problems (persistent paraesthesias, persistent bloody tap)
3. severe headache or backache
4. spinal deformities or arthritis

Preparation and Sterilization

All equipment used for spinal anaesthesia must be carefully cleaned prior to sterilization, but detergents should *not* be used for this purpose. The needles, syringes, and drugs used for spinal anaesthesia must be free of bacterial contamination as well as traces of chemical irritants if neurological sequelae are to be prevented.[69] It has been shown that cold sterilization of anaesthetic drugs or equipment in antiseptic solutions is extremely hazardous because of the potential chance of contamination of the local anaesthetic agents.[69,81] The use of coloured antiseptic solutions is not an adequate safeguard against such contamination. Steam sterilization by autoclaving, using a sterilizer indicator such as a diack control, is probably the simplest as well as the most satisfactory method of assuring proper sterilization of spinal trays and equipment. The indicator must be one in which the chemicals are completely sealed in glass so that potential neurotoxic compounds are not released into the spinal tray. It is preferable to add the local analgesic agents to the spinal tray before sterilization so that the exterior of the ampule as well as the contents will be sterile.

It has been shown that most local anaesthetic agents such as procaine, tetracaine, lidocaine, and dibucaine can withstand multiple autoclaving without loss of potency. Epinephrine can be heat sterilized at least once without undergoing chemical change.[82] Gas sterilization with agents such as ethylene oxide is generally not considered satisfactory for spinal anaesthesia equipment because of the potential chemical activity of the gases used.

CAUSES OF FAILURE OF SPINAL ANAESTHESIA

It is now generally accepted that the primary cause of failure of spinal anaesthesia, other than the obvious administration of an inadequate dose of an acceptable local anaesthetic agent, is the improper deposition of the agent within the subarachnoid space. This may occur if the bevel of the spinal needle is placed partially within the subdural space rather than completely within the subarachnoid space.[83] Hydrolysis of the local anaesthetic agent, as well as excessive acidity or alkalinity of the spinal fluid, are most unlikely explanations of failure.

Conclusions

It has been indicated that no other type of anaesthesia will provide so much for so little, and it is apparent that most of our fears of spinal anaesthesia are unfounded, being based upon the results obtained following its early indiscriminate use. A vast majority of the major complications have been due to the administration of toxic local anaesthetic agents, traumatic spinal needles, and inadequate and improper cleansing and sterilization of the equipment and the local anaesthetic agents used. It is also apparent that a great number of the complications which have been attributed to spinal anaesthesia in the past were actually due to other causes.

Spinal anaesthesia is now well known and well understood. Its limitations have been clearly defined and the indications for its use are generally accepted, as are the physiological principles underlying its application. The great number of uncomplicated spinal anaesthetics which have been recorded during the past decade attest to the relative safety of the local anaesthetic agents themselves. It is therefore suggested that most of the significant complications of spinal anaesthesia, with the probable exception of headache, are not only preventable but also of relatively rare ocurrence following modern techniques of administration.

Résumé

On a démontré qu'aucun autre genre d'anesthésie ne donne tant pour si peu et il apparaît que la plupart de nos craintes au sujet de l'anesthésie rachidienne sont sans fondement; ces craintes sont basées sur les résultats obtenus à la suite de l'usage prématuré et sans discernement de cette technique d'anesthésie.

Une grande majorité des complications graves ont été dûs à l'administration d'anesthésiques locaux toxiques, à des aiguilles traumatisante, à une défectuosité dans le nettoyage et la stérilisation du matériel et des anesthésiques locaux utilisés. Il est également évident qu'un grand nombre des complications attribuées dans le passé à l'anesthésie rachidienne étaient dues en réalité à d'autres causes.

Maintenant l'anesthésie rachidienne est bien connue et bien comprise. Ses limites ont été clairement définies, et ses indications sont généralement reconnues de même que les principes physiologiques sur lesquels repose son application. Le grand nombre de cas sans complications rapportés durant la dernière décade témoignent de la sureté des agents eux-mêmes. On peut alors affirmer que la plupart des complications importantes de l'anesthésie rachidienne, à l'exception peut-être de la céphalée, sont non seulement évitables mais relativement rares à la suite des techniques modernes d'administration.

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