ORIGINAL ARTICLE

Continuous Spinal Anaesthesia – Early Experience in University Hospital, Kuala Lumpur

R Vijayan, FRCA
L Chan, FANZCA
R Raveenthiran, MAnaes
Department of Anaesthesiology,
Faculty of Medicine, University of Malaya,
Lembah Pantai, 59100 Kuala Lumpur

Summary

Continuous spinal anaesthesia using the incremental technique was used in nineteen high risk patients with multiple medical problems, seventeen of whom were elderly, for lower limb orthopaedic and pelvic surgery. An intrathecal catheter (18G/28G) was inserted under local anaesthesia via the lumbar interspinous space. Spinal anaesthesia was induced with small incremental doses of 0.5% bupivacaine hydrochloride through the intrathecal catheter to achieve the level of analgesia required for surgery. The duration of surgery ranged from 45 to 300 minutes (mean + S.D 100 + 37 min). The initial volume of 0.5% bupivacaine required for surgery ranged from 0.8 ml - 2.0 ml (1.2 + 0.7 ml) and the total volume ranged from 0.9 ml to 3.1 ml (mean + S.D 1.4 + 0.7 ml.) Haemodynamic stability was well maintained perioperatively. Only two patients required 6 mg of ephedrine and 1 mg of aramine respectively for a greater than 25% reduction in systolic blood pressure with induction of spinal anaesthesia. Intrathecal morphine 0.1 - 0.3 mg was administered to 15 patients at the end of surgery for postoperative pain relief with good effect. One patient developed late respiratory depression from an inadvertent overdose of intrathecal morphine. No neurological sequelae were noted and no patient developed a postdural puncture headache. The use of the microcatheter was discontinued in the U.S.A and Australia following four case reports of cauda equina syndrome with this technique. Current opinion, however, is that the reported cauda equina syndrome was due to the neurotoxic effects of lignocaine 5% that was used and not due to the microcatheter per se. Continuous spinal anaesthesia is now used widely in Europe when cardiovascular stability is desired in poor risk patients undergoing lower limb and lower abdominal surgery.

Key Words: Continuous spinal anaesthesia, Bupivacaine 0.5%, Geriatric anaesthesia
Lower limb surgery

Introduction

Surgery in elderly patients is associated with higher intra and postoperative morbidity[1]. No particular anaesthetic technique has been demonstrated to be "safe" in geriatric patients[2,3,4]. However, regional anaesthesia is reported to preserve better cerebral function in the postoperative period than general anaesthesia for lower limb surgery in the elderly patient[5].

Continuous spinal anaesthesia (CSA) for lower limb surgery was first described in the 1940s[6,7]. It fell into disuse with the advent of continuous epidural anaesthetic techniques and the high incidence of postdural puncture headaches associated with the use

of large bore needles and catheters available at that time. The development of microcatheters (28G - 32G) has resulted in a renewed interest in the technique[8,9].

CSA has several advantages over both single dose spinal and continuous epidural anaesthesia (CEA) that makes it a very useful technique in the poor risk patient undergoing lower abdominal, pelvic or lower limb surgery[10].

CSA allows one to administer small incremental doses of the local anaesthetic and therefore titrate the dosage to the sensory level obtained in individual patients. Thus doses can be tailored to the patient. This prevents or minimizes the hypotension often seen with single shot spinal techniques.

Pre-loading with crystalloid solution can thus be minimised in patients with marginal myocardial reserves. It allows the local anaesthetic solution to be administered after positioning the patient to reduce cardiovascular instability[11,12].

There is a definite end point in the technique i.e. the visualisation of cerebrospinal fluid (CSF) which increases success of the regional technique. It also requires ten times less local anaesthetic than epidural blockade, eliminating systemic toxic effects. In addition, anaesthesia can be prolonged by incremental doses when surgery is unexpectedly prolonged and small doses of subarachnoid opioids may be administered for prolonged postoperative analgesia[13].

The disadvantages of CSA are that postdural puncture headaches can still occur in younger patients and there is a potential for infection and nerve trauma.

In view of the several advantages of CSA and the availability of the 28G microcatheter kits, we decided to evaluate this technique mainly in elderly "poor risk" patients (ASA III, IV) undergoing lower limb orthopaedic and pelvic surgery in whom maintenance of cardiovascular stability was desirable to reduce or prevent perioperative morbidity.

Materials and Methods

Patients: Elderly patients scheduled to undergo elective lower limb or pelvic surgery under regional anaesthesia. Consent for anaesthesia was obtained from all patients.

Materials: Two types of catheters were used for the CSA technique.

1) The CoSpan™ Catheter kit (Kendall, Mansfield MA) which has a 28G, 91 cm kink resistant catheter with a teflon coated stylet. The spinal needle was of 22G. The kit included a threading assist device, an adapter and 20 micron filter with a priming volume of 0.35 ml.

2) The 18G 'epidural' catheter which was placed in the intrathecal space through an 18G Tuohy needle. The catheter was attached to a filter with a priming volume of 1 ml. A one ml tuberculin syringe was used to administer the local anaesthetic. Bupivacaine 0.5% either plain or hyperbaric was used as the local anaesthetic drug.

Methods: All patients were assessed preoperatively and their general condition noted as per criteria set out by the American Society of Anaesthesiologists (ASA). Their medical problems, drug therapy, preoperative blood pressure and pulse rates were also noted. Midazolam 3.75 mg was given orally two hours prior to surgery, if premedication was deemed necessary.

Anaesthesia

An intravenous crystalloid infusion was set up and the patients positioned either in the lateral decubitus position or sitting up. 10 mg of ketamine was administered intravenously for pain relief during positioning, if necessary. After suitable skin preparation, the subarachnoid space was located in a lumbar interspace using the full aseptic technique. When free flow of cerebrospinal fluid (CSF) was obtained, the catheter was inserted 2 to 3 cm beyond the tip of the needle and the needle withdrawn. An attempt was made to aspirate CSF via the catheter. The catheter was secured with a transparent sterile dressing and taped securely along the patients' back.

The patients were then positioned for surgery on the operating table. The ECG and oxygen saturation (Nellcor-200) were continuously monitored and the

arterial blood pressure recorded with a non-invasive Dinamap at five minute intervals. Spinal anaesthesia was induced by administering 0.5 ml of 0.5% bupivacaine (plain or hyperbaric) using a 1 ml tuberculin syringe. (The priming volume of the filter was taken into consideration). The upper level of sensory block was assessed by the pin prick test and the quality of motor blockade (modified Bromage scale) noted at 3 minute intervals.

Further incremental doses 0.2 - 0.5 ml were given till an adequate level of anaesthesia was obtained. Surgery was then allowed to proceed and the patients were sedated with small bolus doses of midazolam intravenously when clinically indicated. All patients were given supplemental oxygen (2 litres/min) via nasal prongs. A maintenance crystalloid infusion was given at 4 ml/kg/hr. Blood loss was replaced with either blood, colloid or crystalloid depending on the blood volume lost and the clinical situation. Significant hypotension (> 20% of preoperative values) was treated with crystalloid and IV ephedrine or aramine if indicated. Bradycardia (heart rate less than 50 beats/ minute) was treated with intravenous atropine.

The following were noted or measured throughout surgery and into the recovery period: Mean arterial blood pressure and pulse rate every five minutes, the incidence of clinically significant hypotension and bradycardia, the requirements for ephedrine and atropine, duration of surgery; the initial volume of local anaesthetic required for induction and the total volume required; the ease of localising the subarachnoid space, ease of aspiration of CSF.

All catheters were removed at the end of surgery or in the recovery room with the patients' spine fully flexed; any problems encountered with removal was noted; the catheter tips were checked. The patients were reviewed in the ward regularly for one week and incidence of postdural puncture headache, vomiting, fever or neurological deficit, if any, was noted.

Morphine 0.1 mg was administered intrathecally via the catheters in some patients for postoperative pain relief. All patients were monitored in the general wards unless there was a clinical indication for closer observation in the high dependency unit. Hourly respiratory rates and sedation scores were noted besides the blood pressure and pulse rate. Supplemental oxygen was given for twenty four hours postoperatively.

Results

The CSA technique was used in nineteen patients so far. Seventeen patients were elderly and the ages of the patients ranged from 60 to 92 years with a mean age of 77.7 + 7.7 years. There were 11 females and 8 males. The mean weight was 56.2 ± 9.2 kg. It was also used for two young men aged 22 and 25 years with severe ankylosing spondylitis, involving the cervical spine, scheduled for lower limb surgery. The duration of surgery ranged from 45 to 300 minutes (mean ± S.D. 100 + 37 minutes). Two patients underwent transurethral resection of the prostate (TURP) while the rest of the patients had orthopaedic surgery. The majority of patients had medical problems which put them in the high risk category for anaesthesia and surgery. Details of physical status, medical problems and indications for surgery are summarised in Table I.

Catheter Insertion: The intrathecal catheter was inserted in the lateral decubitus position in 16 patients (orthopaedic surgery) while the sitting position was used in three patients including the two patients who underwent TURP. It was possible to establish spinal anaesthesia in all the patients in which it was attempted. In 15 patients the midline approach was used where as the lateral position was used in four patients. In 11 patients the 22 G spinal needle (CoSpan Kit) was used to thread a 28 G microcatheter whereas an 18 G Tuohy needle was used to thread an 18 G catheter into the intrathecal space in the others. Two centimeters of the catheter was inserted with ease in all cases. CSF was easily aspirated via the 18 G catheter while aspiration of CSF via the 28 G was achieved with some difficulty.

No problem was encountered either in catheter insertion or removal. The catheter adapter in the Cospan set was found to be not very satisfactory. Extreme care was needed as it could not be reused if it was accidentally tightened inaccurately in the wrong thread. The catheter tips were all intact on removal.

Table I
Patients' details with their medical problems

No	Age (yrs)	ASA	Medical problems	Indication for surgery	
1.	60	II	Asthma, HPT Hypothyroid	Osteoarthritis	TKR
2.	71	II	Senility	# NOF	Gamma Nail
3.	72	II	Asthma	# NOF	Gamma Nail
4.	72	II	Senility	# NOF	Hip Lock
5.	73	III	HPT, CVA, with stroke, DM	# NOF	Gamma Nail
6.	73	IV	IHD, HPT, DM, Orthopnea, PTB, Arrhythmia	Retention of urine	TURP
7.	74	III	IHD, CVA, COAD Arrhythmia	# NOF	Gamma Nail
8.	74	II	HPT, CVA	Osteoarthritis	TKR
9.	78	II	COAD, Anaemia	# NOF	Gamma Nail
10.	79	III	IHD, HPT, CVA, DM	Retention of urine	TURP
11.	81	II	HPT	# NOF	Gamma Nail
12.	82	III	COAD Chest Infection	# NOF	DHS
13.	83	II	PTB, DM	# NOF	Gamma Nail
14.	91	II	COAD, IHD	# NOF	Hemi-arthroplasty
15.	62	II	–	Osteoarthritis	TKR bilateral
16.	80	III	Aortic stenosis LVF	# NOF	DHS
17.	84	III	MR, Arrhythmias	# NOF	DHS
18.	22	II	Ankylosing Spondylosis	Ankylosed hip	THR
19.	25	II	Ankylosing Spondylosis	# Femur	Removal of plate

HPT – Hypertension; IHD – Ischaemic Heart Disease
COAD – Chronic Obstructive Airway Disease; PTB – Pulmonary Tuberculosis
DM – Diabetes Mellitus; MR – Mitral Regurgitation
LVF – Left Ventricular Function

Anaesthesia

Bupivacaine 0.5% (either plain or hyperbaric) was used in all the patients. Hyperbaric bupivacaine 0.5% (0.5% bupivacaine hydrochloride with 8% dextrose) was used in three patients who were anaesthetised in the sitting position. (TURP and total knee replacement). Plain bupivacaine 0.5% was used in all the other cases. The initial volume of bupivacaine required to establish the required level of anaesthesia for the surgery ranged from 0.8 - 2.0 ml. (Mean and S.D 1.2 + 0.4 ml). The total volume needed for the entire duration of surgery ranged from 0.9 - 3.1 ml. (Mean and S.D 1.4 + 0.7 ml).

Figure 1 shows the relationship between the total volume of local anaesthetic used and the duration of surgery. There was no significant correlation. (R = 0.463).

Figure 2 gives details of the total volume of local anaesthetic required for these patients. More than half the patients (52.6%) required only 1.0 ml or less for the entire surgery. The duration of surgery in these 10 patients ranged from 75 minutes to 150 minutes. The upper level of sensory blockade achieved ranged from T 9 to L 1 dermatome and was adequate for the intended surgical procedure.

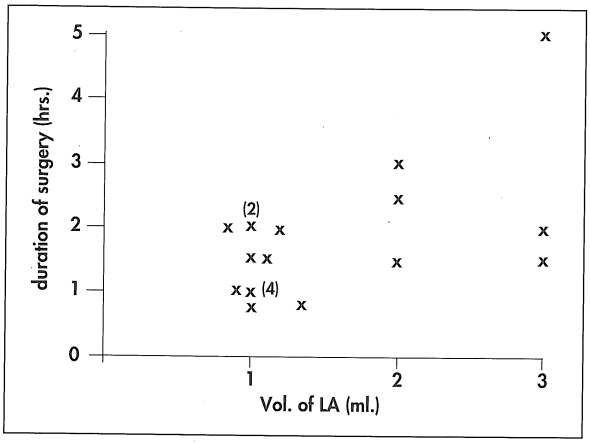

Fig. 1: Relationship between duration of surgery and total volume of local anaesthetic required

Eight patients were given oral midazolam for premedication. The rest of the patients were not given any premedication. Seven patients were given small doses of intravenous midazolam (1 - 2 mg) for intraoperative sedation. Spinal anaesthesia was successful in all patients. No patient required conversion to general anaesthesia.

In fifteen patients 0.1 - 0.3 mg of morphine was administered intrathecally into the CSF via the catheter at the end of the surgery just before the catheter was removed.

Cardiovascular stability

In fourteen patients (73.6%) the lowest recorded drop of systolic blood pressure intraoperatively was less than 20% of preinduction values (Table II).

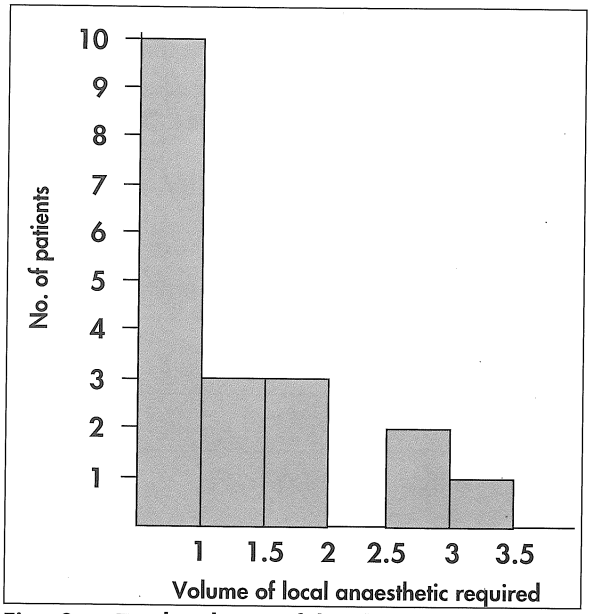

Fig. 2: Total volume of local anaesthetic used

Ephedrine 6 mg was given to one patient and aramine 1 mg to another patient. In both these patients the lowest pressure recorded was > 25%. There were no episodes of bradycardia that required treatment with atropine. Oxygen saturation remained above 95% in all patients till they were discharged from the recovery room. All patients were given supplemental oxygen intraoperatively (2 - 3 litres/ minutes) and this was maintained for twenty four hours after surgery.

Postoperative period

Eighteen patients were nursed in the general orthopaedic ward and one patient was sent to the high dependency ward for observation for twenty four hours. She was a patient with severe aortic stenosis and impaired left ventricular function. The intrathecal catheter was left in situ for twenty four hours and she required two doses of morphine 0.1 mg for postoperative pain relief.

Analgesia

The other fourteen patients who were given intrathecal morphine did not require any potent parenteral opioids in the postoperative period. Oral non-steroidal anti inflammatory drugs was adequate. The other four

Table II
Intraoperative change in systolic blood pressure

Drop from pre-induction values (%)	No. of patients	Percentage
< 5	7	37.0
6 - 10	3	15.7
11 - 15	3	15.7
16 - 20	1	5.3
21 - 25	3	15.7
26 - 30	1 *	5.3
> 30	1 #	5.3
	19	100.0

** 1 mg Aramine # 6 mg Ephedrine*

patients required one dose of subcutaneous morphine for pain relief.

One patient who was given intrathecal morphine became excessively drowsy eight hours after surgery. She was difficult to arouse and had a respiratory rate of 12 breaths/minute. She responded to 0.4 mg of naloxone and was transferred to the High Dependency Unit for overnight observation. Regular observation and monitoring was maintained on a separate Acute Pain Service Monitoring forms in all patients who were given intrathecal morphine.

No neurological deficits were noted in any of the patients after one week. There was no incidence of post dural puncture headache in any of the patients despite the use of 18 G Tuohy needles.

Discussion

The majority of our patients were elderly patients with multiple medical problems, predominantly cardiovascular in nature. Although their symptoms were controlled with multiple drug therapy, as a group, they carried a high risk for anaesthetic morbidity and mortality[14,15]. In addition, fifteen of them required surgery of a semi-urgent nature that could not be postponed or put off. Hole *et al*[5] found that patients who had epidural analgesia for hip replacement surgery had significantly less postoperative mental changes than those who had been given general anaesthesia. Hypoxaemia following anaesthesia and surgery is one of the main causes for postoperative confusion in elderly patients and has been shown to be more common following general anaesthesia[16]. Hypoxaemia can be avoided by supplemental oxygen and is therefore recommended for all elderly patients for at least twenty four hours following surgery.

Haemodynamic stability

Cardiovascular stability is one of the main features of this incremental technique of CSA. Intraoperative vasopressor was required in only two patients (10.6 %) when the lowest drop in systolic blood pressure was greater than twenty-five per cent of preinduction values. (Table II). One was a 70-year-old woman with hypertension and asthma and had been treated for hypothyroidism who required a total knee replacement. Her blood pressure dropped by 26% when the dose was topped up to 2.0 ml (hyperbaric bupivacaine 0.5%). The other was an eighty-three-year-old woman with diabetes mellitus who had 35% reduction in systolic blood pressure with only 1.0 ml of 0.5% bupivacaine plain. CSA has been shown to provide good haemodynamic stability in several studies[17,18]. Striebel-HW *et al* closely monitored the blood pressure of 60 patients undergoing urological surgery either under single shot spinal (SS) or continuous spinal anaesthesia (CSA). The CSA group revealed a significantly more stable blood pressure than the SS group[18].

Petros *et al* also remarked on the remarkable

haemodynamic stability in their experience of 90 patients under an incremental CSA technique[19].

The decrease in mean arterial pressure was found to be more severe with hyperbaric bupivacaine than either isobaric or hypobaric bupivacaine[20]. Isobaric bupivacaine was used in the majority of our patients which could account for the haemodynamic stability although we had insufficient number of patients given hyperbaric bupivacaine for comparison.

Anaesthesia

The total volume of local anaesthetic required was 1.0 ml or less in ten of our patients. (Table II). Petros *et al* also noted that surprisingly small amounts were needed in those patients undergoing lower limb surgery[19]. When using the single shot technique, volumes of local anaesthetic solution larger than really necessary are generally used with a resulting extensive spread of local anaesthetic solutions and a greater drop in blood pressure. This practice of using larger volumes is widespread because of the fear of an inadequate block with smaller volumes. The incremental technique of continuous spinal anaesthesia is therefore particularly suited to administering that volume of local anaesthetic solution necessary for the blockade required. Titrating to effect results in a gradual onset of sympathetic blockade which is responsible for the haemodynamic stability.

Continuous epidural anaesthesia also has the advantage of titrating for effect. The insertion of an epidural catheter is however more difficult in the elderly due to osteoarthritis and calcification of the ligaments. Failure rate is higher in epidural anaesthesia than in spinal anaesthesia[10]. The epidural block may be patchy and requires a much larger volume of local anaesthetic with a higher incidence of systemic toxic effects in this age group.

The duration of surgery ranged from forty-five minutes to five hours. This five fold range in duration would not have been possible with a single shot technique with the small doses used and again illustrates the flexibility of this technique. Bilateral total knee replacement which took five hours was possible with only 3.1 ml of 0.5% of plain bupivacaine. There was no correlation between the duration of surgery and the volume of local anaesthetic required (Fig. 1) which is probably due to the unpredictability of spread of local anaesthetic solution in the intrathecal space[21].

The catheter was easy to insert in all our patients. Kestin *et al* compared incremental spinal anaesthesia with epidural anaesthesia for elective Caesarean section in forty-three mothers. They found that it was easier and quicker to place the spinal catheter and establish spinal anaesthesia than it was using the epidural technique[21]. Haemodynamic stability and the quality of block were similar between the groups. Analysis of failures of spinal anaesthesia in a University Hospital showed that failures with CSA was significantly less than with conventional single shot spinal technique[22]. Locating the intrathecal space is more definite than the epidural space which makes the failure rate with spinal less than epidural anaesthesia.

Adverse effects

Postdural puncture headache (PDPH) is generally not a problem in non ambulating elderly patients following spinal anaesthesia. However, as we were also using the 18 G Tuohy epidural needle to place the epidural catheter in some patients, we were on the alert for PDPH and followed the patients for a week. The two younger patients in whom the 22 G spinal needle and 28 G catheter was used did not develop a headache. PDPH was not a major problem with the CSA technique even in younger patients[9,18,19,23]. On follow up for over a week, we did not encounter any neurological deficits or any signs of infection pertaining to the spinal technique. Rigler *et al* cite four cases of cauda equina syndrome following continuous spinal anaesthesia in which the Cospan 28 G microcatheter was used in three cases and an epidural catheter was used in the fourth[24]. High doses of local anaesthetic were used in these patients following initial focal sensory blockade. A combination of maldistribution and the use of the 5.0% hyperbaric lignocaine have been postulated to have resulted in the neurotoxic injury[25,26]. Cauda Equina Syndrome has also been reported following epidural and single shot spinal techniques[27,28] and is not exclusive to CSA.

Although the use of the microcatheter has been

discouraged in the USA and Australia following the report of the cauda equina syndrome[24] there is growing realisation that it is probably not the catheter but the inappropriate use of high concentration of local anaesthetic that could be the cause[18,19]. Care should therefore be taken in the conduct of CSA and efforts made to avoid administering large doses of local anaesthetic especially when initial focal sensory blockade is found. The technique should be abandoned if adequate spinal blockade is not achieved with the volume or mass of the local anaesthetic solution that would normally be adequate for single shot spinal anaesthesia. Abandoning the technique rather than persisting with larger volumes will avoid any possibility of development of cauda equina syndrome. Kinking of the catheter has been reported resulting in the failure of the technique[29] and Connelly reported on one case of extensive bleeding around the catheter site[30]. In their report describing the evolution of the microcatheter, Hurley and Lambert reported that two of the 32 G microcatheters broke during removal[9]. They attributed it to the inadequate tensile strength. Microcatheters with four times the tensile strength of the older ones are now in use and this should theoretically eliminate problems with breakage. In a more recent report, Pitknen *et al* report breakage (two out of ten) with the 32 G microcatheter and none with the 28 G one[31].

Postoperative analgesia

The presence of the catheter allowed us to administer small doses of morphine (0.1 mg) into the intrathecal space at the end of the surgery. This provided excellent analgesia due to the action of the drug on the spinal opiate receptors. Late respiratory depression has been reported with intrathecal and epidural morphine[32]. It is more likely to occur if large doses of morphine are given intrathecally or if parenteral opiates are also administered[33]. All patients were followed by the Acute Pain Service and monitored regularly in the ward. The respiratory rate and the level of sedation (Sedation Score) was monitored hourly as increasing drowsiness is an early impending sign of respiratory depression[34]. One patient became very drowsy and difficult to arouse ten hours after surgery. She responded to intravenous naloxone and was transferred to a high dependency unit for observation overnight. A check through her anaesthetic notes revealed that an inadvertently large dose of morphine (for her age) was administered which could account for the late respiratory depression. It underscores the fact that these patients can be nursed in a general ward if they are monitored regularly and protocols are readily available for the ward staff when there is a problem.

The two young men in our series had ankylosing spondylitis with a history of difficult intubation and a patchy epidural block during previous anaesthetics. It was decided to try this technique and intrathecal catheters were inserted without a problem and the lower limb surgery proceeded uneventfully.

Conclusion

Spinal anaesthesia has enjoyed a definite place in anaesthesia for the last ninety years. Our experience has shown that the use of small incremental doses of intrathecal local anaesthetic is a valuable extension of the spinal anaesthetic technique in the management of the poor risk elderly patients undergoing lower limb orthopaedic or pelvic surgery. It combines the advantages of epidural with that of spinal anaesthesia, ensures cardiovascular stability and avoids the use of general anaesthesia, manipulation of the airway and ventilation in this group of patients. These advantages will have to be weighed against occasional PDPH which is treatable and the rare neurological complications when considering this technique. It is a technique that all practising anaesthetists should be familiar with.

The 32 G microcatheters should be avoided as they have a higher incidence of technical problems. We also feel that this incremental spinal anaesthesia technique can be undertaken using the Tuohy needle and epidural catheter that is readily available. Inability to obtain the specialised microcatheter kits which are expensive should not be an obstacle to using this technique. It was the expense and the difficulty with the catheter adapter that made us try out the epidural catheter initially.

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References

1. Renck H. The elderly patient after anaesthesia and surgery. Acta Anaesth Scand 1969 Suppl 34 : 9-60.
2. Del Guerco LRM, Cohn JD. Monitoring operative risk in the elderly. JAMA 1980;243 : 1350-5.
3. Valentin N, Lomholt B, Jensen JS, Hejgaard N, Kreisner S. Spinal or general anaesthesia for surgery of the fractured hip? Br J Anaesth 1986;58 : 284-91.
4. Davis FM, Woolner DF, Frampton *et al.* Prospective, multicentre trial of mortality following general or spinal anaesthesia for hip fracture in the elderly. Br J Anaesth 1987; 59 : 1080-8.
5. Hole A, Terjesen T, Bervik H. Epidural versus general anaesthesia for total hip arthroplasy in elderly patients. Acta Anaesth Scand 1980;24 : 279-87.
6. Lemmon WT. A method for continuous spinal anaesthesia. Ann Surg 1940;3 : 141-4.
7. Tuohy EB. Continuous spinal anaesthesia, its usefulness and technique involved. Anaesthesiology 1944;5 : 142-8.
8. Kestin IG, Madden AP, Mulvein JT, Goodman NW. Comparison of incremental spinal anaesthesia using a 32 gauge catheter with extradural anaesthesia for elective Caesarean section. Br J Anaesth 1991;66 : 232-6.
9. Hurley RJ, Lambert DH. Continuous spinal anaesthesia with a microcatheter technique. Preliminary experience. Anesth Analg 1990;70 : 97-102.
10. Sutter PA, Gamulin Z, Forster A. Comparison of continuous spinal and continuous epidural anaesthesia for lower limb surgery in elderly patients - A retrospective study. Anaesthesia 1989;44 : 47-50.
11. Winnie AP. Spinal anaesthesia for hip pinning given with the patient supine. JAMA 1969;207 : 1663-8.
12. Wolffe RC, Upp CW. The prone jack-knife position for the administration of spinal anaesthesia. Anesth Analg 1963;42: 375-8.
13. Wang JK, Nauss LA, Thomas JE. Pain relief by intrathecally applied morphine in man. Anesthesiology 1979;50 : 149-52.
14. Goldman L, Caldera DL, Nussbaum SR *et al.* Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med 1977;297 : 845-50.
15. Goldman L, Caldera DL. Risks of general anaesthesia and elective operation in the hypertensive patient. Anesthesiology 1979;50 : 285-90.
16. Kitmura H, Sawa T, Ikezono E. Postoperative hypoxaemia: the contribution of age to the maldistribution of ventilation. Anesthesiology 1972;36 : 244-52.
17. Kashanipour A, Strasser K, Klimscha W, Taslini R, Aloy A, Semsroth M. Continuous spinal anaesthesia versus continuous epidural anaesthesia in surgery of the lower extremities. A prospective randomised study. Reg Anaesth 1991;14 : (5)83-7.
18. Striebel HW, Holze M, Wessel A. Single shot spinal anaesthesia using the Cospan catheter. Anaesthesiol - Intensivmed - Notfallmed - Schmerzther 1993;23 : 292-9 (German).
19. Petros AJ, Barnard M, Smith D, Ronzoni G, Carli F. Continuous spinal anaesthesia : dose requirements and characteristics of the block. Reg Anaesth 1993;18 : 52-4.
20. Van Gessel EF, Forster A, Schweizer A, Gamulin Z. Comparison of hypobaric, hyperbaric and isobaric solutions of bupivacaine during continuous spinal anaesthesia. Anesth Analg 1991;72 : 779-84.
21. Kestin IG, Madden AP, Mulvein JT, Goodmann NW. Comparison of incremental spinal anaesthesia using a 32 gauge catheter with extradural anaesthesia for elective Caesarean section. Br J Anaesth 1991;66 : 232-6.
22. Brun-Buisson V, Bonnet F, Liu N, Delaunay L, Saada M, Porte F, Homs JB. Analysis of failures of spinal anaesthesia as a function of practice development in a University Hospital. Ann Fr Anaesth Reanimi 1991;10 : 539-42 (French).
23. Denny N, Masters R, Pearson D *et al.* Post dural puncture headache after continuous spinal anaesthesia. Anaesth and Analg 1987;66 : 791-4.
24. Rigler ML, Drasner K, Krejcie TC *et al.* Cauda equina syndrome after continuous spinal anaesthesia. Anesth Analg 1991;72 : 275-81.

25. Morch ET, Rosenberg MK, Truant AT. Lidocaine for spinal anaesthesia. A study of the concentration in the spinal fluid. Acta Anaesth Scand 1957;1 : 105-15.

26. Nicholson MJ, Eversole UH. Neurological complications of spinal anaesthesia. JAMA 1946;132: 679-85.

27. Kane RE. Neurologic deficits following epidural and spinal anaesthesia - Review. Anesth Analg 1981;60 : 150-61.

28. Schou H, Hole P. Neurologic deficit following spinal anaesthesia. Acta Anaesth Belg 1987;38 : 241-3.

29. Morrison LM, McClure JH, Wildsmith JA. Clinical evaluation of a spinal catheter technique in femoro-popliteal graft surgery. Anaesthesia 1991;46 : 576-8.

30. Connelly NR, Hall S. Intraoperative hypotension due to unrecognised bleeding from a continuous spinal catheter site. J Clin Anaesth 1993;5 : 497-9.

31. Pitknen M, Tuominen M, Rosenberg P *et al.* Technical and light microscopic comparison of four different small - diameter catheters used for continuous spinal anaesthesia. Reg Anesth 1992;17 : 288-91.

32. Glynn CJ, Mather LE, Cousins MJ, Wilson PR, Graham JR. Spinal narcotics and respiratory depression. Lancet 1979;2 : 356-9.

33. Davies GK, Tolhurst-Cleaver CL, James TL. Respiratory depression after intrathecal narcotics. Anaesthesia 1980;35 : 1080-3.

34. Ready LB, Oden R, Chadwick *et al.* Development of an Anesthesiology based postoperative pain management service. Anesthesiology 1988;68 : 729-36.