Hemodynamic stability ensured by a low dose, low volume, unilateral hypobaric spinal block: modification of a technique

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Abstract: We report the case of an 89-year-old female with a history of arterial hypertension, intermittent rapid atrial fibrillation and severe aortic valve stenosis, suffering from femoral neck fracture. Hyperbaric unilateral spinal anesthesia is a known technique to obtain stable hemodynamics combined with the possibility of continuous neurologic evaluation and preservation of cognitive functions. Because a hyperbaric unilateral technique can be very painful in case of traumatic hip fracture, a low dose, low volume, unilateral hypobaric spinal block may be an adequate alternative. In the present case report, a unilateral hypobaric spinal anesthesia was performed using 5 mg of bupivacaine in a 1.5 mL volume and a slow and steady, “air-buffered”, directed injection technique, to allow an urgent hip arthroplasty. During surgery the patient was kept in the lateral recumbent position. Hemodynamics remained stable throughout the entire procedure without any need for vasoconstrictors. The impact of aortic valve stenosis combined with atrial fibrillation on anesthetic management and our considerations to opt for a unilateral hypobaric spinal anesthesia are discussed.

Key words: Unilateral spinal; hypobaric; low dose; low volume; aortic valve stenosis.

INTRODUCTION

For most clinicians, severe aortic valve stenosis (AVS) is a reason for preferring general anesthesia to central neuroaxial blockade. Sympathetic block produced by spinal anesthesia can rapidly lead to a decrease in systemic vascular resistance and subsequently to severe myocardial ischemia in patients with AVS (1). When reading current textbooks, spinal block is considered to be contraindicated in these patients (2-5). However, if extensive sympathetic blockade could be minimized or even avoided in the elderly with AVS, most clinicians would probably choose regional blockade, preferring continuous neurological evaluation and preservation of cognitive functions.

The following case describes a low dose, low volume, unilateral hypobaric spinal anesthesia technique, which has clear advantages against a unilateral hyperbaric spinal anesthesia and can ensure hemodynamic stability for hip arthroplasty.

CASE DESCRIPTION

An 89-year-old (172 cm, 60 kg) woman suffering from a left femoral neck fracture was presented to the operating room for urgent hemiarthroplasty. Her medical history included intermittent rapid atrial fibrillation and arterial hypertension for which she was taking atenolol and hydrochlorothiazide, but no anticoagulants. Cardiological examination revealed an irregular heart beat with a grade 3/6 systolic murmur maximal over the second intercostal space on the right side, conducted over both carotids (HR 85 bpm, BP 145/60 mm Hg). A preoperative echocardiogram confirmed left ventricular hypertrophy and AVS. Open aortic valve area was only 0.75 cm² with a maximum gradient of 77 mm Hg and a slightly reduced left ventricular ejection fraction of 50%.

The patient preferred a regional block and the pro’s and con’s of regional anesthesia were discussed with her. She was then premedicated with 3.75 mg midazolam, 50 mg atenolol and 1000 mg paracetamol administered orally one hour prior to transfer to the operation theatre. On arrival, a radial artery catheter was inserted in addition to standard monitoring with ECG and pulse oximetry. Infusion of 500 mL hydroxyethyl starch 6% in sodium chloride 0.9% was started prior to spinal anesthesia.

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With the patient in the right lateral recumbent position, the lumbar area was disinfected. After local anesthetic infiltration of the puncture site, a 25 G Whitacre spinal needle was inserted at the L 3/4 interspace via an introducer needle into the subarachnoid space on the first attempt. The orifice of the needle was turned upwards (toward the non-dependent side). The correct position was verified by visualization of cerebrospinal fluid (CSF) within the transparent Luer-connector of the spinal needle.

Two mL plain bupivacaine 0.5% had been aseptically diluted with 1 mL of sterile water to a final concentration of 0.33%. One and a half mL of this hypobaric bupivacaine 0.33% solution (5 mg) was subsequently steadily administered using an “air-buffered” injection technique at a flow of approximately 0.5 mL/min.

For this purpose, 4 mL of air and 1.5 mL of the hypobaric bupivacaine 0.33% solution was aspirated into a 5 mL syringe which was then held vertically and connected to a three-way stopcock, which in turn was connected to the transparent Luer-connector of the spinal needle. For injection of the local anesthetic solution, the plunger was intermittently depressed in steps of 0.15 mL, resulting in a calculated air pressure of approximately 40 cm of water. Therefore, the compressed air within the syringe became the driving force for injection, resulting in a more steady injection pressure and a slow but steady lowering of the local anesthetic’s meniscus.

After the injection, spread of the block was monitored by cold warm discrimination and pinprick testing. A slight head-up position, guided by the curvature of the patient’s spine, helped to achieve the desired sensory and motor block level on the non-dependent side, without affecting the dependent side. Five minutes after the end of the injection, a T 11 sensory level on the upper left side was obtained. The bed of the patient was then tilted back to stop further cranial spread. After lifting her on the table, the patient was kept in the right lateral recumbent position throughout surgery. On the patient’s request, sedation was started with 5.5 µg/kg/min propofol until the end of the operation. The patient also received oxygen via a nasal cannula (3 L/min) and antibiotic prophylaxis to prevent infection of the prosthesis. The hemodynamic variables remained stable throughout the entire procedure (Fig. 1). There was no need to administer vasoconstrictors. The operation lasted 60 min and

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**Fig. 1. — Vital parameters**

<table>
<thead>
<tr>
<th>x-axis (time)</th>
<th>y-axis (mmHg ; bpm ; %)</th>
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</thead>
<tbody>
<tr>
<td>13:55 = pre-induction</td>
<td>SBP = systolic blood pressure (mm Hg)</td>
</tr>
<tr>
<td>14:00 = spinal anesthesia</td>
<td>DBP = diastolic blood pressure (mm Hg)</td>
</tr>
<tr>
<td>14:20 = incision</td>
<td>MAP = mean arterial blood pressure (mm Hg)</td>
</tr>
<tr>
<td>15:30 = recovery room</td>
<td>HR = heart rate (bpm)</td>
</tr>
<tr>
<td></td>
<td>SpO2 = oxygen saturation by pulse oximetry (%)</td>
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was uneventful with a perfect sensory block and adequate muscle relaxation on the side of surgery. The patient received a total of 1000 mL of hydroxyethyl starch 6% in sodium chloride 0.9% and 500 mL of lactated Ringer’s solution during the procedure. Total blood loss was 800 mL. The patient was then transported to the recovery room awake, alert, and comfortable. Advice was given to the nursing staff to keep the patient in a recumbent horizontal position to prevent hypotension caused by the receding sympathetic block. Postoperative pain was sufficiently controlled with piritramide i.v. and i.m. Three hours after the intrathecal injection, the patient was discharged to the orthopedic ward with completely restored sensory and motor functions. On the ward, no cardiac or circulatory events or other complications like postdural puncture headache or urine retention were seen. Unfortunately, the patient died eighteen days after surgery because of wound infection and subsequent sepsis.

DISCUSSION

If in case of severe AVS, when regional anesthesia is performed, one would usually prefer epidural anesthesia over single-shot spinal anesthesia, because of the more gradual onset of the sympathetic block (6, 7). However, epidural anesthesia will inevitably cause a bilateral sympathetic block and is therefore considered relatively contraindicated in patients with severe aortic stenosis (2-5).

Sympathetic blockade following spinal anesthesia can rapidly cause a decrease in venous return with a subsequent decrease in cardiac output and, most importantly in case of AVS, a decrease in afterload and thus a drop in systemic blood pressure severely affecting coronary perfusion pressure. Obstruction to outflow of the left ventricle in AVS leads to concentric myocardial hypertrophy and elevated ventricular diastolic pressures, which makes the myocardium more susceptible to hypotension.

Due to a decreased diastolic pressure gradient between the left atrium and left ventricle in patients with AVS, ventricular filling becomes dependent on atrial kick. Loss of atrial systole in case of atrial fibrillation can then precipitate congestive heart failure and/or severe hypotension. Abrupt changes in intravascular volume should be avoided because of reduced ventricular compliance that turns the patient very sensitive for these changes. A normal heart rate is important because these patients have a more or less fixed stroke volume and cardiac output is directly dependent upon heart rate. Bradycardia and tachycardia are poorly tolerated and therefore heart rates between 60 and 90 bpm are optimal in these patients (2, 4, 5).

A promising modification of a conventional single shot spinal anesthesia is the unilateral hyperbaric or hypobaric technique (8-13). Better control of the extent of the sympathetic block by a unilateral hyperbaric spinal anesthesia results in minimal hemodynamic side effects (8, 10). If small volumes of a hyperbaric bupivacaine solution are slowly and steadily injected, a bilateral sympathetic block can be avoided in two-thirds of the patients, as has been shown by skin temperature measurement (8, 14). With regard to hemodynamics, the success of this unilateral spinal technique depends upon dose, volume, and injection flow, or to be precise in terms of physics, ouflow speed of the local anesthetic. Horlocker et al. found a higher level of a conventional spinal block following fast injection, which can be associated with sympathetic blockade also including the cardioaccelerator fibers (15). Also for bilateral spinal anesthesia, Atchison et al. reported that a slow injection of hypobaric tetracaine produced lower block levels that tended to be of longer duration than levels resulting from a fast, conventional injection (16). Enk et al. concluded that an injection flow of 7.5 mL/min leads to turbulence and mixing of the local anesthetic with the CSF, also causing a more extended sympathetic block, because the preganglionic sympathetic fibers are not myelinated and will therefore be blocked even by low concentrations of local anesthetics.

In contrast, a slow and steady injection of a hyperbaric solution at a rate of 0.5 mL/min will make the CSF floating on top of a layer of the hyperbaric local anesthetic solution without turbulence-induced mixing effects. Due to reduced mixing, a smaller volume is sufficient for an adequate block. This can also limit adverse redistribution effects following change in position of the patient (14). Comparing equal doses in a hyperbaric and hypobaric solution, Kaya et al. found a lower incidence of unilateral spinal block for the hypobaric solution. He administered 4.2 mL of the hypobaric bupivacaine 0.18% solution at an injection rate of 3 mL/min (12).

Based on the findings of these authors, it is apparent that a conventional injection of greater volumes of a hypobaric local anesthetic will most likely cause a high level sympathetic block with relevant hemodynamic consequences. For this reason, we combined a hypobaric spinal anesthesia with the low dose, low volume, slow injection
concept resulting in a low dose, low volume, unilateral hypobaric technique. While we routinely use this technique in relatively healthy patients for hip replacement, we were convinced that this technique would also be superior in our patient with severe AVS.

The patient had to be turned once only onto the non-affected side in her bed, while manually immobilizing the fractured leg to limit pain from movement. After successful spinal puncture, the slow and “air-buffered” injection of the hypobaric local anesthetic, with the orifice of the 25 G Whitacre needle directed towards the affected side, provided immediate and effective pain relief. Due to the surgical technique, the patient could be kept in the lateral recumbent position throughout the entire operation, including lifting and positioning on the table, thereby keeping the local anesthetic on the side of surgery with limited risk of redistribution to the other side. In addition, there are physiological reasons for our approach. In contrast to a hyperbaric technique, a head-down position is possible during a hypobaric spinal at any time. Especially in case of sudden hypotension, right ventricular preload and left ventricular afterload can immediately be increased this way without any risk of further cranial spread of the local anesthetic. Compared to the administration of additional infusion volume and/or vasoconstrictors, this is a quicker way to stabilize the circulation.

Due to lack of temperature data, we can only speculate that we have obtained a unilateral sympathetic block. Nevertheless, the stable condition of our patient throughout the entire procedure without any need of intervention with vasoactive drugs at any time and the uneventful postoperative follow-up supports the correctness of our practical and physiological considerations. The likelihood of minimal hemodynamic derangement turns the concept of unilateral hypobaric spinal anesthesia into an option for cardiovascularly-compromised patients. However, further evaluation is required.

References