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Prevention of arterial hypotension after spinal anaesthesia using vena cava ultrasound to guide fluid management

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Abstract

Background: Significant hypotension is frequent after spinal anaesthesia and fluid administration as therapy is usually empirical. Inferior vena cava (IVC) ultrasound (US) is effective to assess fluid responsiveness in critical care patients. The aim of this study was to evaluate the IVCUS-guided volume optimization to prevent post-spinal hypotension.
Methods: In this prospective, randomized, cohort study, 160 patients scheduled for surgery under spinal anaesthesia were randomized into a study group (IVCUS-group), consisting of an IVCUS analysis before spinal anaesthesia with IVCUS-guided volume management and a control group (group C) with no IVCUS assessment. The primary outcome was a relative risk reduction in the incidence of hypotension between the groups; secondary outcomes were the need for vasoactive drugs and the amounts of fluids required after spinal anaesthesia. We also tested the hypothesis of a correlation between IVC collapsibility index and hypotension after spinal anaesthesia.
Results: The relative risk reduction of hypotension between the groups was 35% (IVCUS-group 27.5%, Group C 42.5%, $P=0.044$, CI=95%). The need for vasoactive drugs in the IVCUS-group was significantly lower compared to the C-group ($P=0.015$), while the total amount of fluids was significantly superior higher in the IVCUS group ($P<0.0001$) compared to Group C. IVC collapsibility index was correlated with the amount of fluid administered ($r^2=0.32$), but could not be used to predict postspinal anaesthesia hypotension.
Conclusions: IVCUS is an effective method to prevent postspinal anaesthesia hypotension by IVCUS-guided fluid administration before spinal anaesthesia.
Clinical trial registration: www.clinicaltrials.gov - NCT02271477.

Key words: fluid responsiveness; inferior vena cava collapsibility index; inferior vena cava ultrasound; transthoracic echocardiography; spinal anaesthesia

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Editor's key points

- Hypotension is common after spinal anaesthesia especially in the elderly.
- Pre-emptive intravenous fluid loading may be used before spinal anaesthesia but has the potential for volume overload.
- In this study, pre-emptive fluid therapy guided by inferior vena cava (IVC) ultrasound resulted in a lower incidence of postspinal hypotension and lower requirements for vasopressors.
- Use of IVC ultrasound was associated with higher volumes of fluid administration before spinal anaesthesia but the total volumes of fluid were similar in the ultrasound and control groups.
- These data suggest that IVC ultrasound may help optimize fluid status before spinal anaesthesia.

The most common side effects of spinal anaesthesia are bradycardia and hypotension.[1 2] The reduction in both cardiac output and systemic vascular resistance (SVR) contributes significantly to spinal anaesthesia-induced hypotension. However, in the elderly population (average age 68–72 yr) the physiology of spinal-anaesthesia-induced hypotension seems to be different compared to younger patients. At T4–T6 sensory levels of spinal anaesthesia, SVR decreases by 23–26%, central venous pressure by 2–3 mm Hg, and left ventricular end diastolic volume by 20%. The higher degree of resting sympathetic tone exhibited by elderly patients may explain the important decrease in SVR to sympathetic blockade compared with younger patients.[3]

The most predictive variable for developing spinal-anaesthesia-induced hypotension is peak sensory block level at or above T5 [odds ratio (OR) 3.8]. Other risk factors are chronic alcohol consumption (OR 3.1), emergency surgery (OR 2.8), age >40 yr (OR 2.5), history of hypertension (OR 2.2), baseline systolic blood pressure <120 mm Hg (OR 2.4), combined spinal/general anaesthesia (OR 1.9), and spinal puncture at or above L2-L3 interspace (OR 1.8).[1 4 5]

To minimize haemodynamic impairment, preventive empiric volume loading is commonly performed in obstetric anaesthesia before injecting the local anaesthetic.[6] However, this carries the potential for volume overload, with particular risks for patients with cardiac disease.[7] Furthermore, several studies of prophylactic volume loading to prevent spinal anaesthesia-induced hypotension have provided inconsistent results, mostly due to different definitions of hypotension, different patient populations (surgical, elderly, obstetric), and the concomitant use of vasopressor therapy included in the study design. Therefore, blind volume preloading before spinal anaesthesia in non-obstetric patients undergoing spinal anaesthesia is not regularly performed.[6]

Inferior vena cava (IVC) ultrasound (US) has been used in spontaneously breathing intensive care patients[8] and few data are available patients who are not critically ill.[9] Moreover, stroke volume calculations using aortic velocity time integral have been shown to accurately correlate with fluid responsiveness.[10] The variation of the IVC diameter with spontaneous breathing can be assessed in its intra-abdominal portion (ideally at 2 cm from the right atrium) for clinical use.[11] However, there is no evidence for its clinical use in the elective, preoperative setting. Recently, Zhang et al[12] identified the IVC collapsibility index (cIVC) measurement as a reliable predictor of arterial hypotension after induction of general anaesthesia. However, this has not been studied in patients undergoing spinal anaesthesia,.

The aim of this study was to evaluate the IVCUS-guided volume optimization to prevent post-spinal anaesthesia hypotension in spontaneously breathing ASA 1–3 patients for elective non-cardiovascular, non-obstetric surgery. The primary outcome was a reduction in the incidence of hypotension. Secondary outcomes were the requirement for administration of vasoactive drugs after the procedure and the total volume of fluids required throughout anaesthesia. Moreover, we analysed if preoperative cIVC was useful to predict the incidence of hypotension after spinal anaesthesia.

Methods

After approval by the Ethical Committee (Ethical Committee Bellinzona – Switzerland; April 2014, Chair: Prof. G. Zanini - N CE2796), registration in clinicalTrial.gov (NCT02271477), and written informed consent, we enrolled 185 consecutive ASA 1–3 patients aged 18–65 yr scheduled for non-cardiovascular, non-obstetric surgery under spinal anaesthesia in this prospective, randomized, cohort study. The study flowchart according to the CONSORT statement is shown in Fig. 1.[13] Exclusion criteria were: the need for invasive blood pressure monitoring according to institutional guidelines, a pre-existing arterial hypotension [defined as two measurements of systolic arterial pressure <90 mm Hg and/or a mean arterial pressure (MAP) <60 mm Hg], absolute contraindications or failure to perform spinal anaesthesia and patients scheduled for unilateral spinal anaesthesia.

The patients included were randomized into two groups in block of six, according to a computerized random list. A person not involved in the enrolment centrally handled the randomization list to guarantee allocation concealment. Patients were randomized at individual level, using the method of minimization incorporating a random element; the minimization factors were the age (cut off 65 yr), the ASA status (level III or level I/II intended as 'not III'), any assumption of antihypertensive therapy (intended as β-blockers or angiotensin-converting enzyme inhibitors) or any psychoactive therapy (selective serotonin reuptake inhibitors, tricyclic antidepressants, monoamine oxidase inhibitors). The anaesthesiologist in charge of the case was blind to the respective group allocation.

Preoperative fasting started 6 h before surgery and water intake was possible until 2 h before surgery. At arrival in the induction room, a standard non-invasive monitoring (continuous ECG, non-invasive blood pressure measurements every minute and peripheral saturation) was applied and a 18G i.v. line was placed. No pre-spinal anaesthesia fluid load was applied to any patient.

The spinal anaesthesia procedure was standardized: patient positioning in the lateral decubitus position, and after disinfection and sterile covering spinal anaesthesia was performed at the L3-L4 lumbar space using a 27G pencil point bevelled spinal needle (B. Braun Medical SA, Melsungen, Germany). A standard dose of heavy bupivacaine 0.5% (12–18 mg depending on surgery and patient's constitution) was injected slowly with the needle orifice oriented cranially. After injection, patients were immediately positioned supine for 30 min before surgery. Meanwhile, the non-invasive blood pressure was measured every minute and vital parameters were