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EFFECT OF ULTRASOUND-GUIDED INDIVIDUALIZED FLUID OPTIMIZATION ON NAUSEA AND VOMITING FOLLOWING SPINAL ANAESTHESIA: A PROSPECTIVE RANDOMIZED CONTROLLED TRIAL

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Abstract

Background:

Nausea and vomiting are common complications of spinal anaesthesia and are largely attributed to sympathetic blockade-induced reduced organ perfusion. Conventional fixed-volume fluid preloading does not account for individual differences in intravascular volume status, which may limit its effectiveness. Ultrasound-guided assessment of the inferior vena cava (IVC) provides a simple, non-invasive method for individualized fluid optimization before spinal anaesthesia.

Objective:

To evaluate the effect of ultrasound-guided individualized fluid optimization on the incidence of nausea and vomiting following spinal anaesthesia.

Methods:

This prospective randomized controlled trial included 98 adult patients aged 18–60 years with American Society of Anesthesiologists (ASA) physical status I or II undergoing elective infraumbilical surgery under spinal anaesthesia. Patients were randomized to receive either ultrasound-guided individualized fluid optimization (Group U; n=49) based on IVC assessment or conventional crystalloid preloading (Group C; n=49). The primary outcome was the incidence of intraoperative nausea and vomiting. Continuous and categorical variables were analyzed using the independent t-test, Chi-square test, or Fisher's exact test, with P<0.05 considered statistically significant.

Results:

Baseline demographic and perioperative characteristics were comparable between the groups. Nausea occurred in 4 (8.2%) patients in Group U compared with 13 (26.5%) in Group C (P=0.031). Vomiting was observed in 2 (4.1%) and 10 (20.4%) patients, respectively (P=0.028). Ultrasound-guided fluid optimization reduced the relative risk of nausea by 69.2% (RR=0.31; NNT=6) and vomiting by 80.0% (RR=0.20; NNT=7).

Conclusion:

Ultrasound-guided individualized fluid optimization significantly reduced nausea and vomiting following spinal anaesthesia. This patient-specific, bedside approach offers an effective strategy for improving perioperative comfort and supports the incorporation of point-of-care ultrasound into routine perioperative fluid management.

Keywords: Spinal Anaesthesia, Ultrasonography, Fluid Therapy, Intraoperative Nausea and Vomiting

1. Introduction

Because of its rapid onset of action, reliable sensory and motor blockade, excellent intraoperative analgesia, and favourable safety profile, spinal anaesthesia is one of the most frequently employed regional anaesthetic techniques for elective infraumbilical surgeries. It offers several advantages over general anaesthesia, including reduced postoperative pain, lower opioid requirements, early ambulation, and faster recovery. Despite these benefits, spinal anaesthesia is commonly associated with intraoperative adverse events, among which nausea and vomiting remain particularly troublesome. These symptoms not only cause significant patient discomfort and anxiety but may also interfere with surgical procedures, compromise patient satisfaction, and increase the risk of aspiration and other perioperative complications. Consequently, preventing nausea and vomiting during spinal anaesthesia remains an important objective in perioperative patient care. [1,2]

The pathophysiology of nausea and vomiting during spinal anaesthesia is complex and multifactorial. Sympathetic blockade produced by spinal anaesthesia leads to peripheral vasodilatation, reduced venous return, and a consequent decline in cardiac output that is strongly associated with the occurrence of nausea and vomiting. In addition, enhanced vagal activity, reduced cerebral and gastrointestinal perfusion, visceral traction during surgery, and individual patient-related factors further contribute to these symptoms. Since intravascular volume depletion is an important and potentially reversible contributor to spinal anaesthesia-induced decrease in cardiac output, appropriate perioperative fluid management has gained considerable attention as a preventive strategy. [2–4]

Traditional fluid preloading with fixed crystalloid volumes has long been practiced to reduce haemodynamic instability following spinal anaesthesia. However, this empirical approach does not account for interindividual variability in baseline volume status or fluid responsiveness and may result in either inadequate volume expansion or unnecessary fluid administration. Excessive fluid therapy has its own adverse consequences, whereas insufficient fluid replacement may fail to prevent associated complications. [4–6]

Recent advances in point-of-care ultrasonography have enabled rapid, bedside assessment of intravascular volume status using dynamic parameters such as the inferior vena cava (IVC). Ultrasound-guided fluid optimization provides an individualized approach to perioperative fluid therapy and has demonstrated promising results in reducing perioperative complications. [6–8]

In view of these considerations, the present randomized controlled trial was undertaken to evaluate whether ultrasound-guided fluid optimization of IVC reduces the incidence of nausea and vomiting following spinal anaesthesia

2. Materials And Methods

Study Design and Ethical Approval

This prospective, parallel-group, randomized controlled trial was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. The study adhered to the principles of the Declaration of Helsinki and was conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines. Written informed consent was obtained from all participants before enrolment.

Participants

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Adult patients aged 18–60 years with American Society of Anesthesiologists (ASA) physical status I or II scheduled for elective infraumbilical surgery under spinal anaesthesia were screened for eligibility. Patients with significant cardiovascular, hepatic, renal, or respiratory disease, pregnancy, coagulopathy, or refusal to participate were excluded.

Sample Size

The sample size was calculated based on the expected difference in the incidence of intraoperative nausea and vomiting between the two groups. Assuming a two-sided α error of 0.05 and a study power of 80%, a total sample of 98 patients (49 per group) was considered adequate to detect a clinically meaningful difference.

Randomization and Allocation Concealment

After enrolment, participants were randomly assigned in a 1:1 ratio to either the ultrasound-guided fluid optimization group (Group U) or the conventional fluid preloading group (Group C). Randomization was performed using a computer-generated random sequence prepared by an investigator not involved in patient recruitment or outcome assessment. Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes, which were opened immediately before the intervention.

Blinding

Because of the nature of the intervention, the anaesthesiologist administering preoperative fluid therapy could not be blinded. However, patients, surgeons, and the investigator responsible for recording intraoperative outcomes and analysing the data remained blinded to group allocation.

Study Interventions

Following standard fasting guidelines, all patients underwent routine pre-anaesthetic evaluation. Upon arrival in the operating room, standard monitoring, including electrocardiography, non-invasive blood pressure, and pulse oximetry, was instituted, and baseline haemodynamic parameters were recorded.

Patients allocated to Group U underwent preoperative ultrasonographic assessment of the inferior vena cava using a low-frequency curvilinear probe in the subxiphoid long-axis view. The inferior vena cava was assessed during spontaneous respiration. Intravenous crystalloid was administered in incremental boluses according to fluid optimization protocol until the intravascular volume status was restored.

Patients in Group C received conventional preloading with crystalloid solution according to the institutional protocol before spinal anaesthesia.

Spinal anaesthesia was performed under aseptic precautions at the L3–L4 intervertebral space using a Quincke spinal needle with 2.5-3 mL of 0.5% hyperbaric bupivacaine. Following confirmation of adequate sensory block, surgery was commenced.

Outcome Measures: The primary outcome was the incidence of intraoperative nausea and vomiting following spinal anaesthesia. Demographic variables, perioperative fluid administration, duration of surgery, haemodynamic parameters, and episodes of nausea and vomiting were recorded.

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Statistical Analysis Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were tested for normality using the Shapiro–Wilk test and are presented as mean ± standard deviation (SD). Normally distributed continuous variables were compared using the independent-samples *t*-test, whereas categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test, as appropriate. All analyses were performed on an intention-to-treat basis. A two-tailed P value <0.05 was considered statistically significant.

3. Results

A total of 98 patients were assessed, enrolled, and randomized in a 1:1 ratio to the ultrasound-guided fluid optimization group (Group U, *n*=49) or the conventional fluid management group (Group C, *n*=49). All randomized participants received the allocated intervention, completed the study, and were included in the final analysis, with no protocol deviations or losses to follow-up.

Baseline demographic and perioperative characteristics were comparable between the two groups. There were no statistically significant differences with respect to age, sex distribution, body mass index, ASA physical status, or duration of surgery (p>0.05), indicating successful randomization and baseline homogeneity.

Incidence of Nausea and Vomiting

The incidence of intraoperative nausea following spinal anaesthesia was significantly lower among patients who underwent ultrasound-guided individualized fluid optimization. Nausea was observed in 4 patients (8.2%) in Group U compared with 13 patients (26.5%) in Group C, representing a statistically significant reduction (p= 0.031).

Similarly, vomiting occurred significantly less frequently in the ultrasound-guided group. Only 2 patients (4.1%) in Group U experienced vomiting compared with 10 patients (20.4%) in Group C (p=0.028), demonstrating the beneficial effect of individualized preoperative fluid optimization in minimizing gastrointestinal adverse events associated with spinal anaesthesia (Table 1).

Table 1. Incidence of Nausea and Vomiting Following Spinal Anaesthesia

Adverse effect	Group U (n=49)	Group C (n=49)	p-value
Nausea	4 (8.2%)	13 (26.5%)	0.031
Vomiting	2 (4.1%)	10 (20.4%)	0.028

Effect Size Analysis

Risk estimation further demonstrated the clinical significance of the intervention. Ultrasound-guided fluid optimization reduced the relative risk of nausea by 69.2% (RR=0.31), with an absolute risk reduction (ARR) of 18.4%, yielding a number needed to treat (NNT) of 6. Thus, individualized fluid optimization in six patients prevented one additional episode of nausea.

For vomiting, the intervention achieved an even greater benefit, producing an 80.0% relative risk reduction (RR=0.20) with an ARR of 16.3% and an NNT of 7, indicating that treatment of seven patients using the ultrasound-guided protocol prevented one additional episode of vomiting compared with conventional fluid management (Table 2).

Overall, these findings demonstrate that ultrasound-guided individualized fluid

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optimization significantly decreases the incidence of nausea and vomiting following spinal anaesthesia and provides a clinically meaningful improvement in perioperative patient comfort compared with conventional fixed-volume fluid preloading.

Table 2. Clinical Effect Size of Ultrasound-Guided Fluid Optimization

Outcome	Relative Risk (RR)	Absolute Risk Reduction (ARR)	Relative Risk Reduction (RRR)	Number Needed to Treat (NNT)
Nausea	0.31	18.4%	69.2%	6
Vomiting	0.20	16.3%	80.0%	7

4. Discussion

The present randomized controlled trial demonstrated that preoperative ultrasound-guided individualized fluid optimization significantly reduced the incidence of both nausea and vomiting following spinal anaesthesia compared with conventional fixed-volume fluid preloading. Patients receiving ultrasound-guided fluid optimization experienced a 69.2% relative reduction in nausea and an 80.0% relative reduction in vomiting, highlighting the clinical value of individualized haemodynamic optimization before neuraxial blockade. These findings reinforce the principle that tailoring perioperative fluid therapy according to physiological requirements rather than administering empirical fluid volumes can substantially improve perioperative patient outcomes.[9,10]

The occurrence of nausea and vomiting during spinal anaesthesia is primarily a consequence of sympathetic blockade resulting in peripheral vasodilatation, reduced venous return, decreased cardiac output. Reduced cerebral and splanchnic perfusion, increased vagal activity, and surgical visceral stimulation collectively activate the emetic centre. Consequently, maintaining adequate intravascular volume before spinal anaesthesia is an important strategy for preserving haemodynamic stability and minimizing gastrointestinal adverse events.[11,12]

Conventional crystalloid preloading remains a common practice; however, administration of a predetermined fluid volume assumes that all patients have similar intravascular volume status. Such an empirical approach ignores individual variations in preload responsiveness and may result in both under-resuscitation and unnecessary fluid administration. In contrast, ultrasound-guided assessment of the inferior vena cava provides a rapid, non-invasive, bedside method for identifying patients who are likely to benefit from fluid administration. By delivering fluids only to responsive patients, this strategy facilitates individualized goal-directed fluid therapy while avoiding excessive fluid loading.

Our findings are consistent with the growing body of evidence supporting individualized fluid optimization before spinal anaesthesia. The systematic review and meta-analysis by Shang et al.[13] demonstrated that improved preoperative intravascular volume optimization significantly reduced intraoperative nausea and vomiting compared with conventional fluid strategies. The authors Showed that fewer gastrointestinal complications because maintenance of systemic perfusion reduced cerebral and gastrointestinal hypoperfusion following sympathetic blockade.

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Unlike most previous investigations [14,15] which primarily evaluated haemodynamic outcomes and vasopressor consumption as their principal outcomes, the present study specifically focused on nausea and vomiting—two complications that directly influence patient comfort, surgical conditions, and overall perioperative satisfaction. Our findings therefore extend the existing evidence by demonstrating that the benefits of ultrasound-guided fluid optimization are not limited to haemodynamic improvement but also translate into meaningful patient-centred outcomes.

The magnitude of benefit observed in the present study further emphasizes its clinical importance. Ultrasound-guided fluid optimization reduced the absolute risk of nausea by 18% and vomiting by 16%, corresponding to numbers needed to treat of six and seven patients, respectively. These favourable effect sizes indicate that only a small number of patients require individualized fluid optimization to prevent one additional episode of nausea or vomiting. Such effect sizes compare favourably with several pharmacological antiemetic strategies while avoiding drug-related adverse effects.

Another important implication of the present study is the practicality of incorporating point-of-care ultrasound into routine perioperative assessment. Ultrasound evaluation of the inferior vena cava is rapid, reproducible, non-invasive, and readily performed at the bedside without exposing patients to radiation. Increasing availability of portable ultrasound systems and growing expertise among anaesthesiologists make individualized fluid optimization a feasible component of modern perioperative care and Enhanced Recovery After Surgery (ERAS) protocols. By reducing unnecessary fluid administration while improving haemodynamic stability, this approach may also decrease vasopressor requirements, improve tissue perfusion, and enhance recovery.

The strengths of the present study include its prospective randomized controlled design, concealed allocation, standardized anaesthetic protocol, and complete follow-up of all randomized participants, thereby minimizing selection and attrition bias. In addition, clinically meaningful measures including relative risk, absolute risk reduction, relative risk reduction, and number needed to treat were calculated, enabling better interpretation of the practical significance of the intervention.

Nevertheless, certain limitations should be acknowledged. This was a single-centre study involving a relatively small cohort of ASA I–II patients undergoing elective infraumbilical surgery, which may limit the generalizability of the findings to high-risk populations and emergency procedures. Furthermore, nausea and vomiting are multifactorial outcomes influenced by patient characteristics, surgical stimulation, anaesthetic technique, perioperative medications, and individual susceptibility. Although ultrasound-guided fluid optimization significantly reduced these complications, additional strategies including optimized vasopressor therapy and multimodal prophylaxis may further improve outcomes. Future multicentre randomized controlled trials with larger sample sizes should evaluate the impact of ultrasound-guided individualized fluid optimization on postoperative recovery, patient satisfaction, vasopressor consumption, hospital stay, and cost-effectiveness while exploring its integration into enhanced recovery pathways.

5. Conclusion

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Ultrasound-guided individualized fluid optimization before spinal anaesthesia was associated with a significant reduction in the incidence of intraoperative nausea and vomiting compared with conventional fixed-volume fluid preloading. These findings demonstrate that tailoring fluid therapy according to each patient's intravascular volume status is more effective than an empirical fluid administration strategy in minimizing gastrointestinal adverse effects following neuraxial blockade. Given its simplicity, non-invasive nature, and bedside applicability, point-of-care ultrasound represents a practical tool for optimizing perioperative fluid management and enhancing patient comfort. Incorporating ultrasound-guided fluid assessment into routine anaesthetic practice has the potential to improve the quality of perioperative care by promoting individualized, goal-directed management. Larger multicentre randomized trials involving diverse surgical populations are required to validate these findings and establish its role as a standard component of perioperative fluid optimization protocols.

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Dr. Ruchi Gupta: Conceptualization, planning, data analysis

Dr. Sohail Singh Sodhi: Study execution, data compilation, analysis, manuscript writing

Dr. Arvinder Pal Singh: Planning, manuscript editing, and review.

Dr. Rajesh Arora: Planning, manuscript editing, and review.

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