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ORIGINAL ARTICLE

Effects of Goal-Directed Fluid Therapy Guided by Inferior Vena Cava Collapsibility Index on Hemodynamics and Enhanced Recovery in Patients Undergoing Lower Limb Surgeries: A Randomized Study

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ABSTRACT

Background: Goal-directed fluid therapy (GDFT) guided by IVC Collapsibility Index maintains euvolemia and enhances recovery under the Enhanced Recovery After Surgery (ERAS) protocol. The primary aim of the study was to record the effect of GDFT guided by IVC Collapsibility Index and conventional fluid management on Mean Arterial Pressure (MAP). The secondary aim was to measure heart rate (HR), oxygen saturation (SpO2), peripheral perfusion index (PPI), intraoperative fluid intake, intraoperative urine output, incidence of hypotension or bradycardia and the number of patients that received Atropine and Ephedrine in patients undergoing lower limb orthopedic surgeries under spinal anesthesia.

Methods: This prospective randomized controlled trial was performed on 46 patients allocated into two groups: the GD group (n=23) received intraoperative fluid management guided by IVC collapsibility index, while the C group (n=23) followed conventional fluid therapy.

Results: The GD group had significantly lower intraoperative fluid intake (978.26±270.87 mL vs. 1623.91±138.06 mL, p=0.0001) and urine output (264.13±106.29 mL vs. 400±116.53 mL, p=0.0001). The GD group also demonstrated significantly reduced PACU stay (2.5 vs. 3.9 hours, p=0.029), shorter hospital stays (12 vs. 16 days, p=0.0373), and higher QoR-40 scores (188.44±4.33 vs. 184.26±4.69, p=0.003). intraoperative hemodynamics were comparable between the studied groups (p>0.05). However, both groups did not experience substantially different postoperative complications (p>0.05).

Conclusions: Ultrasound inferior vena cava collapsibility index is a non-invasive, reliable and effective method to guide intraoperative Goal-Directed Fluid Therapy and enhanced recovery with stable hemodynamics in patients undergoing lower limb orthopedic surgeries under spinal anesthesia compared to traditional method of fluid therapy.

Keywords: Inferior Vena Cava Collapsibility Index; Goal-Directed Fluid Therapy; Hemodynamics; Lower Limb Surgeries.

INTRODUCTION

Optimizing perioperative fluid administration plays a crucial role in determining patient outcomes [1]. Lack of fluid maintenance during the surgical phase may lead to hypovolemia and impaired tissue perfusion, ultimately exposing patients to severe complications like acute kidney injury (AKI) and myocardial infarction [2]. Conversely, too much fluid

can also harm the patient by causing tissue edema, pulmonary congestion, delayed wound healing, a higher potential for wound infection, and gastrointestinal edema-the latter being a possible determinant of postoperative ileus [3].

Enhanced recovery after surgery (ERAS) protocol allows for various modes of intervention, systems of medicine, and technologies to be employed to optimize the patient's care provided in the perioperative stage. Goal-directed fluid therapy (GDFT), within the ERAS guidelines, is another avenue for ensuring appropriate fluid management by concentrating on restricting enough fluid intake to prevent dehydration while minimizing the risk for tissue hypoperfusion [4]. Adoption of ERAS protocol is also associated with significant results such as a reduction of 30-50% in lengths of hospital stay, a similarly proportional decrease in complication rates, and significantly reduced readmissions into hospitals [5-7].

The fluid therapy was aimed at restoring euvolemia based on dynamic indicators of volume responsiveness [8]. Central venous pressure (CVP) has been the most commonly used parameter for fluid resuscitation assessment, but studies revealed that it does not accurately measure blood volume, while yet many clinicians continue to use it around the world [9].

Non-invasive parameters for assessing fluid responsiveness in GDFT have increased and diversified. While some depend on sophisticated technology that is unavailable in limited-resource settings, others will still be feasible enough to find within a hospital with limited facilities [10]. Commonly now accepted as useful measures of intravascular volume status has been the measurement of inferior vena cava (IVC) diameter. Side by side, the advantages of IVC collapsibility over CVP assessment are that it is less invasive and much easier. Recent evidence finds further support to show that CVP does not correlate with actual blood volume; hence, IVC measurements can also be useful in fluid management [9].

So, this study's primary outcome was to record the effect of GDFT and conventional fluid management on Mean Arterial Pressure. The secondary outcomes were heart rate, oxygen saturation, peripheral perfusion index, intraoperative fluid intake, intraoperative urine output, incidence of hypotension or bradycardia and the number of patients that received Atropine and Ephedrine.

METHODS

This randomized controlled study was performed on forty-six patients undergoing lower limb surgeries at Anesthesia, Intensive Care and Pain management Department, Faculty of Medicine, Zagazig University Hospitals for six months from March 2024 to September 2024.The method of randomization was computer-generated random numbers with the use of sealed opaque envelopes for allocation concealment.

After institutional review board (IRB) approval (ZU-IRB#11122), all participants were asked to sign an informed consent. Human subjects research adhered to the guidelines set in the Declaration of Helsinki, which is part of the World Medical Association's Code of Ethics.

Preoperative Phase

One day before surgery, the study objectives and expected outcomes were explained to the patients, and written informed consent was obtained. A thorough medical and surgical history was recorded, and necessary laboratory investigations, including complete blood count, partial thromboplastin time, prothrombin time, and kidney and liver function tests, were performed. Patients were instructed to fast from solid food for six hours before surgery. On the day of the operation, an intravenous

(IV) line was inserted, and patients received 0.03 mg/kg of midazolam.

Intraoperative Phase

Patients were transferred to the operating room, where standard monitoring devices (GE Monitor B40i) were applied, including a non-invasive blood pressure cuff, pulse oximeter for SpO2 and peripheral perfusion index, a temperature probe, and ECG leads. Baseline vital parameters were recorded, and the inferior vena cava (IVC) collapsibility index was measured using a GE Logiq 5 ultrasound machine with a subcostal approach and a curved probe. The collapsibility index was calculated as follows:

IVC Collapsibility Index = (Maximum Diameter on Expiration - Minimum Diameter on Inspiration) / Maximum Diameter on Expiration

A central venous catheter (CVC) was inserted to measure central venous pressure (CVP), and a urinary catheter was placed for urine output monitoring.

Spinal Anesthesia Procedure

The procedure was performed under aseptic conditions with the patient in a sitting position. After sterilization, the intervertebral spaces L3–L4 and L4–L5 were palpated, and the most accessible site was chosen for spinal anesthesia. Local anesthesia was administered before inserting a 22G or 25G spinal needle via the median or paramedian approach. A combination of 25 µg fentanyl and 15 mg heavy bupivacaine 0.5% was injected into the subarachnoid space. The patient was then placed in a supine position with slight head elevation.

Study Groups:

Goal-Directed Fluid Therapy Group (GD Group; n=23)

Patients in this group received 400 mL of carbohydrate-rich clear fluids two hours preoperatively. Intraoperative fluid administration was guided by IVC diameter measurements, obtained via a subcostal approach using a GE Logiq 5 ultrasound machine. The IVC collapsibility index was calculated using two-dimensional and M-mode imaging.

A collapsibility index greater than 36% indicated fluid responsiveness, while a value below 36% suggested non-responsiveness. IVC diameter was assessed immediately after spinal anesthesia induction and every 10 minutes thereafter. Fluid-responsive patients received an initial 500 mL crystalloid bolus over 10 minutes, followed by reassessment of IVC variation. If necessary, additional 250 mL crystalloid boluses were administered until a non-responder pattern was observed. This protocol was maintained throughout the perioperative period.

Control Group (C Group; n=23)

Patients in the control group fasted for six hours preoperatively and received intraoperative fluids according to standard guidelines. Before the administration of spinal anesthesia, they were given a preload of 1000 mL crystalloid infusion. The maintenance fluid requirement was calculated based on body weight, with 4 mL per kilogram for the first 10 kg, 2 mL per kilogram for the next 10 kg, and 1 mL per kilogram for the remaining weight. To compensate for fasting, the maintenance requirement was multiplied by the number of fasting hours, with half administered in the first hour and the remainder in the second hour.

Hemodynamic Management

During the procedure hemodynamic stability was continuously monitored. Mean arterial pressure (MAP) decreased greater than 20% from baseline for ephedrine to be given in 5 mg IV increments up to a maximum dose of 50 mg. If heart rate fell more than 20% from baseline, atropine would be given at a dose of 0.01 mg/kg IV. Also documented were the total number of patients requiring either

ephedrine or atropine and total intraoperative fluid intake.

Postoperative Phase

The post-anesthesia care unit (PACU) was utilized in order to ensure that patients were monitored continuously following surgery. Patients developed postoperative complications, which were regarded as hypotension (with MAP decrease by more than 20%), bradycardia (with HR drop by more than 20%), nausea, and vomiting. Urine output and central venous pressure (CVP) were also monitored to assess fluid balance. The QoR-40 score, validated for postoperative recovery assessment, was calculated for every patient. Evaluation of recovery also included PACU duration and total hospital length of stay.

Data Collection:

***Preoperative Data**

The patient's demographics consisted of age, sex, body mass index (BMI), and American Society of Anesthesiologists (ASA) physical status. Hemodynamic parameters recorded at baseline were MAP, heart rate (HR), saturation of peripheral oxygen (SpO2), and peripheral perfusion index (BMC Pulse Oximeter M130). Also measured were the IVC collapsibility index and central venous pressure (CVP) at baseline.

***Intraoperative Data**

During surgery, hemodynamics were monitored using MAP and HR at 5-minute intervals. Any incidences of hypotension or bradycardia, defined as falling more than 20% from baseline values, would be noted. Measurements were made concerning the IVC collapsibility index, every 10 minutes, the peripheral perfusion index, and SpO2 were taken every 5 minutes. Urinary output was used to assess renal perfusion, and total cumulative operative fluid intake was noted. It also enumerated the number of patients who required ephedrine or atropine.

***Postoperative Data**

Postoperative monitoring included the incidence of hypotension, bradycardia, nausea, and vomiting. The duration of PACU stay (in minutes) (the time between the patient's transfer to PACU until their discharge to the ward) was observed for assessing early recovery. The QoR-40 score was employed for the evaluation of five domains: patient support (7 items), comfort (12 items), emotions (9 items), physical independence (5 items), and pain (7 items), assessing overall postoperative well-being with a total mean from 40 to 200. The total length of stay in hospital (in days)(the time elapsed between a patient's hospital admittance and discharge)was also reported.

Study Outcomes

The primary outcome of the study was comparing the effect of goal-directed fluid therapy (GDFT) vs. conventional fluid management on mean arterial pressure. Secondary outcomes included heart rate, oxygen saturation, peripheral perfusion index, intraoperative fluid balance, urine output, and the incidence of hypotension and bradycardia. Additionally, the need for ephedrine or atropine was analyzed to assess hemodynamic stability under both fluid management strategies.

Statistical analysis

Sample size: Considering the mean ± SD of mean arterial blood pressure(MAP) in Goal-Directed Fluid Management group was (82.6 ± 15.5) mmHg and (69.4 ± 8.1) mmHg in Liberal Fluid Management group [11], the total sample size would be 46 with 23 patients in each group using open epi software with power 95% and confidence interval 95%. 52 patients were recruited in the study for any possible dropouts (Open Epi), 4 of them were excluded for not meeting the inclusion criteria and 2 of them were excluded because they underwent general anesthesia. The remaining 46 patients were randomized into two different groups with 23 patients in each group.The

data of the 23 patients from each group was analyzed (Figure 1).

For data compilation, tabulation, and analysis, we relied on IBM SPSS Statistics for Windows, Version 23.0, released by IBM Corp. in 2015. Qualitative data was represented by percentages and figures, whereas quantitative data was shown by the mean plus or minus the standard deviation. Two sets of normally distributed variables were compared using the t test. The Mann-Whitney U test was employed to compare two non-normally distributed sets of data. The percentages of categorical variables were compared using either the Fisher exact test or the Chi-square test. Every one of the exams might go either way. A p-value of less than 0.05 was considered a statistically significant result, whereas a p-value of 0.05 or more was considered a non-significant result.

Patients eligible for the study provided consent and were scheduled for elective lower limb surgery under spinal anesthesia. Inclusion criteria included both sexes, ages 21–65, BMI <35, ASA Class I or II, and a surgery duration of 2–3 hours.

Exclusion criteria included advanced systemic diseases, contraindications to spinal anesthesia, or conversion to general anesthesia. Patients could withdraw anytime without affecting their care. Withdrawal was mandatory if patient required blood transfusion due to severe blood loss, defined as a hemoglobin drop below 8 g/dl.

RESULTS

Non statistically significant variations were revealed between the study groups concerning age, sex, body mass index, ASA PS I and II, or the duration, type of surgery (Table 1), intraoperative MAP ($p > 0.05$) (Figure 2) or intraoperative HR($p > 0.05$)(Figure 3), intraoperative SpO2($p > 0.05$) or intraoperative PPI($p > 0.05$).

The GD Group revealed a statistically significant reduction in both intraoperative total fluid intake and urine output compared to the C Group ($p < 0.05$) (Table 2).

Non statistically significant variation was found between the studied groups in the number of patients who required intraoperative Ephedrine or Atropine ($p > 0.05$) (Table 3).

In comparison to the C Group, the GD Group showed a statistically significant decrease in PACU stay time ($p = 0.029$), an increase in the QoR-40 score ($p = 0.003$), and a decrease in hospital length of stay (LoS) ($p = 0.0373$). Non-significant variation was shown as regards the incidence of postoperative nausea, vomiting ($p = 0.99$) or hypotension ($p = 0.99$) between the groups that were investigated. Table 4 also shows that neither group experienced bradycardia after the operation.

Table (1): Demographic data, Duration and type of surgery between the studied groups

Parameters	**C group N=23**	**GD Group N=23**	**t-test/ χ2**	**p-value**
Age (years)	42.56±14.83	45.26±10.39	0.714	0.479
BMI (kg/m^2)	27.83±3.98	26.34±4.59	1.174	0.247
Sex N (%) Females Males	9(39.1%) 14(60.9%)	6(26.1%) 17(73.9%)	0.980	0.345
ASA PS N (%) I II	16(69.6%) 7(30.4%)	17(73.9%) 6(26.1%)	0.107	0.743
Duration of surgery (min)	139.13±18.32	130.87±12.76	1.775	0.083
Type of surgery	**N (%)**	**N (%)**	2.286	0.808
• Total Hip Arthroplasty	3(13.04%)	4(17.39 %)		

Parameters	C group N=23	GD Group N=23	t-test/ χ2	p-value
• Total Knee Arthroplasty	5(21.74 %)	3(13.04%)		
• Hip Hemiarthroplasty	3(13.04%)	5(21.74 %)		
• Trochanteric Fracture Fixation	4(17.39 %)	3(13.04%)		
• Femoral Nonunion Fixation & Bone Graft	5(21.74 %)	3(13.04%)		
• Acetabulum Fracture Open Reduction & Internal Fixation	3(13.04%)	5(21.74 %)		

Data are expressed as Number (%) or mean ± standard deviation (SD)
American Society of Anesthesiologists Physical Status (ASA PS), BMI: Body Mass Index
t: student's t-test, χ2: Chi-squared test,
P value ≥ 0.05: not significant

Table 2: Intraoperative total fluid intake and Total Urine Output (UoP) between studied groups

Parameters	C group N=23	GD Group N=23	t-test	p-value
Intraoperative total fluid intake (mL)	1623.91±138.06	978.26±270.87	10.185	0.0001*
Intraoperative total UoP (mL)	400±116.53	264.13±106.29	4.131	0.0001*

Data are expressed as mean ± standard deviation (SD)
Total UoP: total urine output
t: student's t test
**** P value <0.05: significant***

Table 3: The number of patients who needed Ephedrine or Atropine between the studied groups

Variables	C group N=23	GD Group N=23	χ2	p
Number of patients who needed Ephedrine **N (%)**	7(30.43%)	9(39.13%)	0.383	0.536
Number of patients who needed Atropine **N (%)**	1(4.35%)	2(8.70%)	f	0.99

Data were expressed as Number (%)
χ2: Chi-square test, f: Fisher exact test
P value ≥ 0.05: not significant

Table 4: Post-anesthesia Care Unit (PACU) stay, Length of Stay (LoS) in hospital, QoR-40 score , and post-operative complications between the studied groups

Parameters	C group N=23	GD Group N=23	u-test/ t-test	p-value
PACU stay (hours)	3.9(2-7.1)	2.5(2-3.4)	2.188 u	0.029*
LOS in hospital (days)	16(12-19)	12(9-17)	2.082 u	0.0373*
QoR-40 score	184.26±4.69	188.44±4.33	3.141 t	0.003*
Post-operative Complications				

Variable	C group N=23	GD Group N=23	fP-value
Nausea N (%)	1(4.35%)	1(4.35%)	-
Vomiting N (%)	1(4.35%)	0	0.99
Hypotension N (%)	1(4.35%)	2(8.70%)	0.99

Data are expressed as median (interquartile range) (IQR) or mean ± standard deviation (SD)
LoS in hospital: length of stay in hospital
PACU: post anesthesia care unit
QoR: Quality of Recovery
u: Mann Whitney u test
***P value < 0.05: significant**

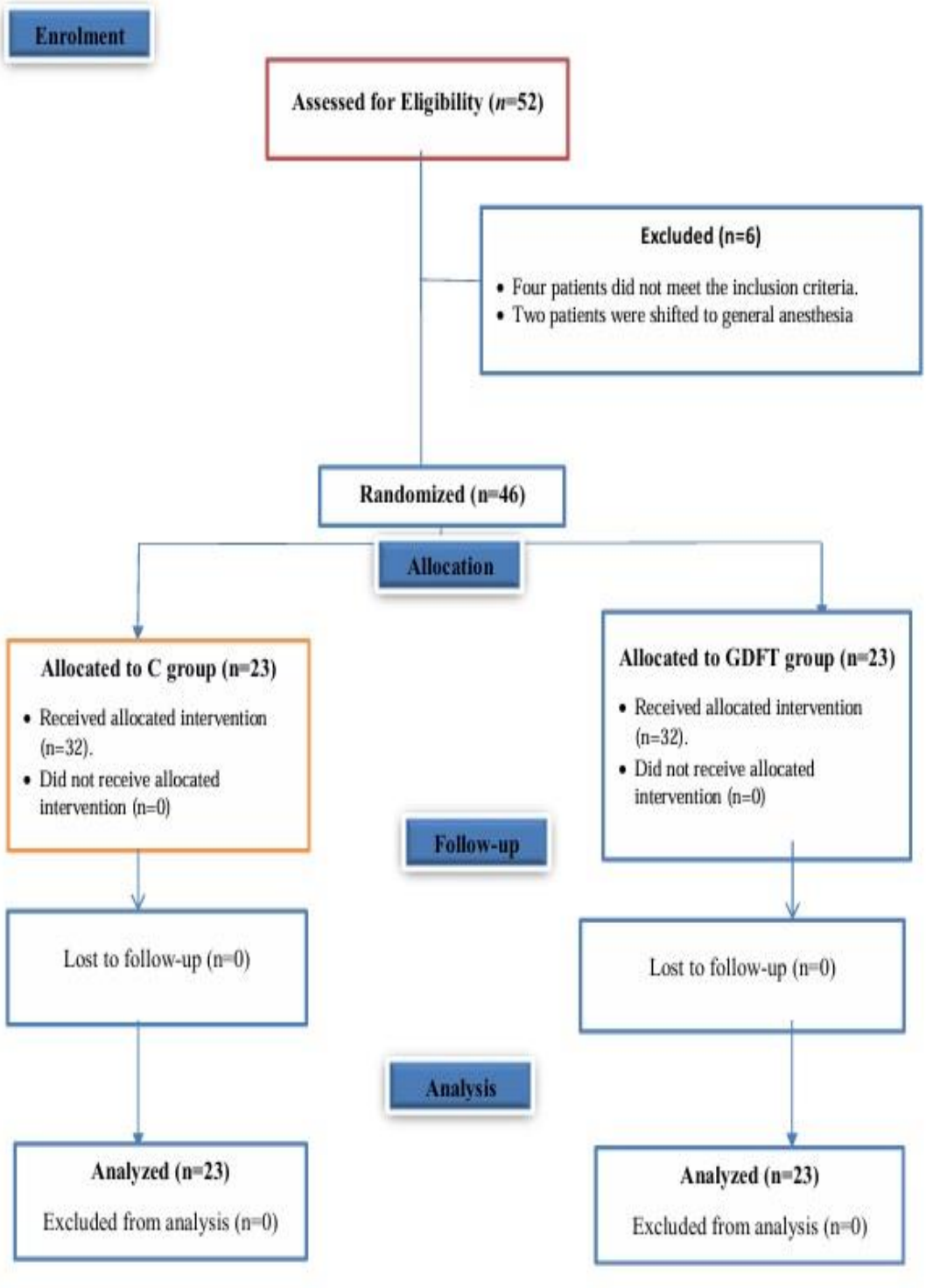

Figure 1 : Consort Flow Chart

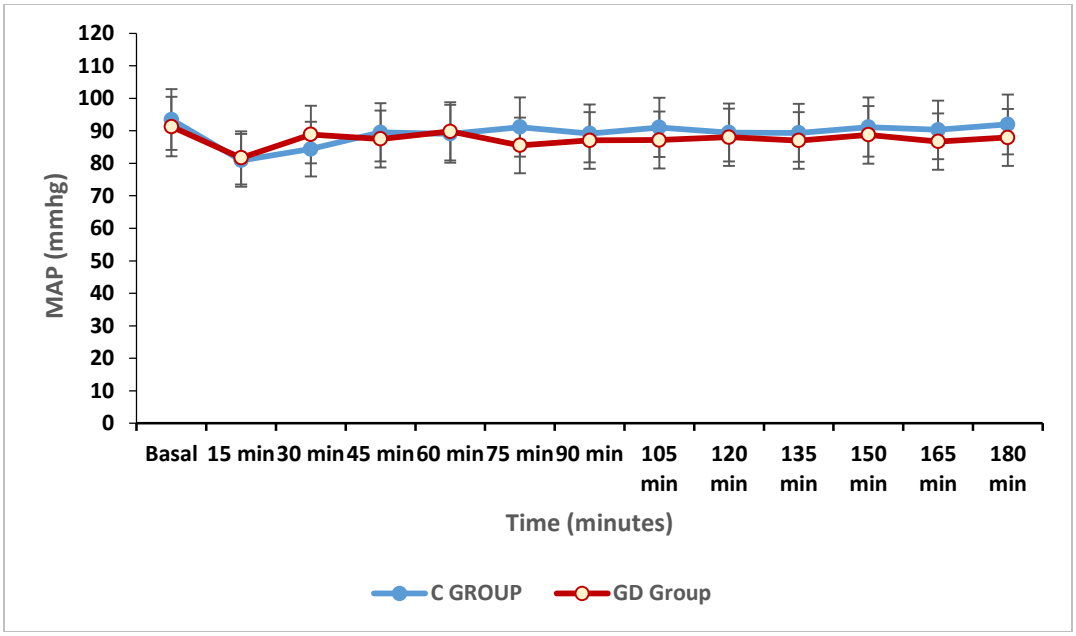

Figure 2: The mean value of intraoperative Mean Arterial Pressure (MAP) (mmHg) between studied groups at the measured time points

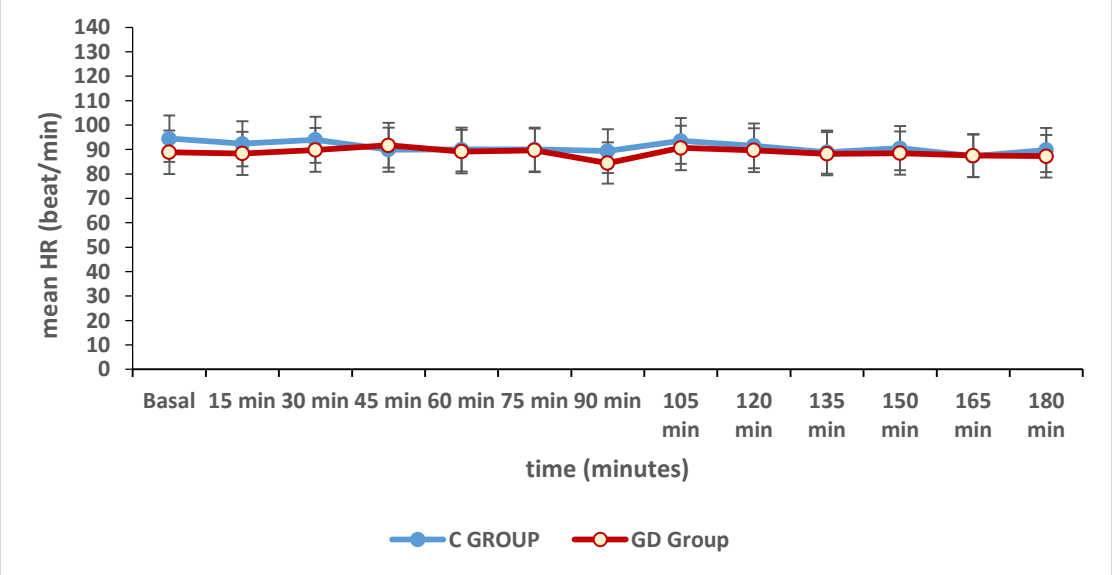

Figure 3: The mean value of intraoperative heart rate (HR) (beat/min) between studied groups at the measured time points

DISCUSSION

The present study demonstrated that Ultrasound Inferior Vena Cava Collapsibility index is a reliable, non-invasive and effective method to guide intraoperative Goal-Directed Fluid Therapy compared to the traditional method of fluid therapy with stable hemodynamics, shorter PACU stay, hospital stay and better enhanced recovery scores in patients undergoing lower limb orthopedic surgeries under spinal anesthesia. Also, Goal-Directed Fluid Therapy resulted in a statistically significant decrease in intraoperative total fluid intake and intraoperative urine output.

Fluid management is critical in surgeries under spinal anesthesia due to its role in maintaining hemodynamic stability, preventing complications, and enhancing recovery. Spinal anesthesia-induced sympathetic blockade can cause vasodilation and hypotension, necessitating precise fluid administration to support tissue perfusion and cardiac output [11]. Both fluid overload and hypovolemia pose risks—excessive fluids can lead to edema and delayed recovery, while inadequate fluids can result in tissue hypoperfusion. Thus, Goal-Directed Fluid Therapy is of great importance in perioperative anesthetic care, particularly in the unique hemodynamic context of spinal anesthesia [12].

Negative consequences for patient outcomes can result from fluid imbalance, which can occur because of either too much or too little fluid delivery. Pulmonary edema, poor gas exchange, and an increased strain for the heart can result from fluid overload, also known as hypervolemia [13,14]. Complications including congestive heart failure and extended hospital stays can follow. On the other side, low blood volume (hypovolemia) raises the risk of acute kidney damage, organ dysfunction, and poor tissue perfusion [15]. There is evidence that fluid imbalance in surgical patients increases the risk of postoperative complications, slows recovery, and even increases mortality [16,17]. Optimizing hemodynamic stability and promoting patient recovery requires precise fluid management measures, such as goal-directed fluid therapy.

Compared to the conventional method of fluid therapy, the current study showed that the Ultrasound Inferior Vena Cava Collapsibility Index is a dependable, non-invasive, and effective way to guide intraoperative goal-directed fluid treatment. Patients undergoing lower limb orthopedic procedures under spinal anesthetic benefited from stable hemodynamics, a shorter PACU stay, a decreased hospital stay and improved enhanced recovery scores. Results showed a marked decrease in both urine production and total fluid intake with goal-directed fluid therapy.

A substantially reduced volume of fluid was sufficient to produce stable hemodynamics that did not differ significantly between the two groups. This method aids in avoiding the negative consequences of fluid overload.

Consistent with our findings, Bloria et al. [18] examined 50 adults who were scheduled for an urgent craniotomy to clip aneurysms. At random, 25 patients were assigned to group G, which underwent goal-directed fluid therapy guided by left ventricular outflow tract velocity time integral (LVOT-VTI), and 25 patients were assigned to group C, which underwent CVP-guided fluid management. Even though patients in group G received 2503.6±534.3 mL of fluid compared to 3732.8±676.5 mL in group C, there was no change in Mean Arterial Pressure between the two groups ($P < 0.0001$).

Much like this, Mostafa et al. [19] divided 100 patients evenly between two groups: one that received liberal fluid therapy (LFT) and another that received GDFT. During the operation, patients in the group that received goal-directed fluid therapy received much

less fluid than those in the LFT group. In terms of perfusion markers, such as serum lactate and creatinine, however, the groups that were compared did not differ significantly.

Abdelrahman et al. [20] compared intraoperative GDFT with conventional fluid therapy (CVFT) and found no differences in intraoperative serum lactate levels between the groups. However, the GDFT group received significantly less crystalloid fluids than the CVFT group.

A study by Habicher et al. [21] compared 130 patients in GDFT group with 130 historical matched control patients. The PACU/ICU stays of patients in the control group were substantially longer than those in the GDFT group (960 minutes (360-1210) vs. 400 minutes (207-825); p <0.001). Consistent with our results, the GDFT group also received far fewer crystalloids than the control group.

Forty patients having surgery for a massive supratentorial tumor were divided into two groups by randomization, according to Mishra et al. [22]. Fluid therapy was administered to the control group according to normal hemodynamic monitoring, while the GDFT group was directed to follow stroke volume variation (SVV) as a guidance. The GDFT group necessitated substantially less fluid overall (P = 0.003). The GDFT group also experienced fewer surgical complications and a shorter hospital stay (P = 0.07).

Sun et al. [23] also found that patients who received goal-directed hydration therapy stayed in the hospital for shorter periods of time. A hundred patients slated for elective major abdominal surgery under general anesthesia were split into two groups: one that received standard fluid therapy (group C) and another that received a GDFT treatment (group G). The stroke volume variation (SVV) and cardiac index (CI) were used to guide the GDFT protocol in Group G, while standard fluid therapy based on MAP and CVP was used in Group C. The duration of hospital stay for group G was greatly reduced compared to group C (9.0±5.8 days vs. 12.0±4.6 days, P = 0.001). Furthermore, GDFT significantly cut down on the time it took to start experiencing flatulence by 11 hours (P = 0.009) and the time it took to start tolerating oral meals by 2 days (P < 0.001). These improvements in gastrointestinal recovery likely contributed to the higher quality of recovery (QoR-40) scores reported by patients.

A study by Aaen et al. [24] compared GDT with standard therapy (STD) in 312 adult patients with gastrointestinal obstruction or perforation; nevertheless, the results were contradictory. Patients in the STD group receive intravenous fluids according to standard practice; whereas, patients in the GDT group receive fluids to achieve near-maximal stroke volume. The research found that the duration of hospital stay was significantly longer for the GDT group (7 (range 4-12) days vs. 6 (range 4-8.5) days) compared to the control group (P=0.04). This discrepancy in results may be explicable by the differences in the nature and site of the surgical intervention.

In contrast to our work, Turkut et al. [25] used the FloTrac device for GDT in their randomized controlled trial of 60 patients divided into two groups of 30 patients each. As long as the control group's mean arterial pressure was higher than 65 mmHg and their urine production was greater than 0.5 mL/kg/h, the anesthesiologist determined the appropriate fluid dosage. In the study group, fluid management was guided by a target stroke volume variation of ≤13%. The research group significantly consumed more fluids overall (P = 0.0455) and stayed in the hospital for a longer period of time (P = 0.012) than the control group.

Results regarding hemodynamics, lactate kinetics, and vasoactive agent needs showed

no statistically significant differences in the present investigation. While Turkut et al. [25] used stroke volume variation as their GDT approach, the current investigation used the inferior vena cava (IVC) collapsibility index, which could explain the observed variation in results. Additional research comparing these approaches is suggested.

Mathew et al. [26] performed a randomized controlled experiment on 42 children who were going to have elective open colon surgery. The kids were randomly assigned to either the liberal group, which received standard liberal intraoperative fluids, or the GDT group, which received goal-directed intraoperative fluids. Optimal fluid administration in pediatric surgery patients may be achieved using goal-directed techniques, as the study indicated that the liberal group received 37.0 ± 8.9 mL/kg of intraoperative fluid, while the GDT group received 24.1 ± 9.6 mL/kg.

In agreement with the current study, Moharari et al. [27] compared Goal-Directed Fluid Therapy with Regular Fluid Therapy in patients undergoing spine surgery and concluded that fluid intake was significantly lower in the GDT group. No differences were observed in the incidence of hypotension or bradycardia, and the length of hospital stay was significantly shorter in the GDT group, reinforcing the potential benefits of goal-directed approaches in optimizing perioperative fluid management.

The present study had certain limitations. First, the relatively short period of follow up, so we need longer follow up to accurately judge long term outcomes such as: surgical site infection, wound healing and hospital readmission. Secondly, people having orthopedic procedures on their lower limbs while under spinal anesthesia were the only ones we looked at to see how goal guided fluid treatment worked. Patients receiving general anesthesia and other surgical procedures may benefit from the study.

CONCLUSIONS

Ultrasound inferior vena cava collapsibility index is a non-invasive, reliable and effective method to guide intraoperative Goal-Directed Fluid Therapy and enhanced recovery with stable hemodynamics among patients undergoing lower limb orthopedic surgeries under spinal anesthesia compared to traditional method of fluid therapy.

Recommendations

Some other aspects could be investigated in future research such as:

- Comparing different intraoperative methods for volume status assessment such as: pulse pressure variation, stroke volume variation and central venous pressure with inferior vena cava collapsibility index.
- Study the effect of GDFT implementation on a different group of patients undergoing surgeries other than lower limb orthopedic surgeries.
- Investigating the use of ultrasound inferior vena cava collapsibility index as a guide for GDFT in patients undergoing general anesthesia

Conflict of Interest: None.
Financial disclosure: None.

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