ORIGINAL RESEARCH

Comparative Study on the Hemodynamic Stability of Spinal vs. General Anesthesia in Patients Undergoing Interventional Radiology Procedures

[1]Dr. Ravi Tej Maruvada, [2]Dr. Sumra Mukesh Manubhai, [3]Dr. Akshay Kumar, [4]Dr. Madhur Jain

[1]Assistant Professor, Department of Anaesthesia, Maharajah's Institute of Medical Sciences, Nellimarla, Andhra Pradesh, India
[2]Assistant Professor, Department of Medicine, ICARE Institute of Medical Sciences and Research & Dr Bidhan Chandra Roy Hospital, Haldia, West Bengal, India
[3]Assistant Professor, Department of Radiology, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India
[4]Assistant Professor, Department of Medicine, People's College Of Medical Sciences & Research Centre, Bhopal, MP, India

Corresponding Author
Dr. Madhur Jain
Assistant Professor, Department of Medicine, People's College Of Medical Sciences & Research Centre, Bhopal, MP, India

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ABSTRACT
Aim: This study aims to evaluate and compare the hemodynamic stability of spinal anesthesia (SA) versus general anesthesia (GA) in patients undergoing interventional radiology procedures. **Materials and Methods:** A total of 110 patients scheduled for elective interventional radiology procedures were enrolled in this prospective comparative study. The patients were divided into two groups: the SA group (n = 55) and the GA group (n = 55). Hemodynamic parameters, including heart rate (HR), mean arterial pressure (MAP), and oxygen saturation (SpO_2), were monitored preoperatively, intraoperatively, and postoperatively. Primary outcomes included variations in HR and MAP, as well as the incidence of hypotension and bradycardia. Secondary outcomes included vasopressor use, postoperative nausea and vomiting (PONV), pain scores, recovery time, and hospital stay. **Results:** The study found that the SA group exhibited significantly lower HR and MAP compared to the GA group at multiple intraoperative time points. The incidence of hypotension was higher in the SA group (30.91%) compared to the GA group (18.18%). Postoperative pain scores were significantly lower in the SA group at 1, 6, and 24 hours postoperatively ($p < 0.05$), and the SA group also had a lower incidence of PONV (10.91%) compared to the GA group (21.82%). Recovery time and hospital stay were shorter in the SA group (45.12 ± 5.34 minutes and 2.87 ± 0.76 days, respectively) compared to the GA group (60.34 ± 6.12 minutes and 3.65 ± 0.89 days). **Conclusion:** Spinal anesthesia offers superior postoperative analgesia, reduced PONV, and faster recovery compared to general anesthesia in patients undergoing interventional radiology procedures. However, it is associated with greater intraoperative hemodynamic suppression, requiring closer monitoring and more vasopressor support. SA may be the preferred technique in cases where improved recovery and pain management are desired, with careful management of hemodynamic stability.

Keywords: Spinal Anesthesia, General Anesthesia, Hemodynamic Stability, Postoperative Pain, Recovery Time.

INTRODUCTION

Interventional radiology (IR) has transformed modern medicine, offering minimally invasive procedures that reduce recovery times, surgical risks, and overall patient burden. With advancements in imaging-guided interventions, IR procedures have become a preferred alternative for many conditions that traditionally required open surgery. However, the success of these procedures is influenced by multiple factors, including patient comorbidities, the complexity of the intervention, and, importantly, the choice of anesthesia. Anesthesia management in IR settings presents unique challenges due to prolonged procedure times, the need for precise patient positioning, and the requirement for hemodynamic stability to ensure optimal imaging and procedural success. Among the anesthetic techniques available, spinal anesthesia (SA) and general anesthesia (GA) are two commonly employed methods, each with distinct physiological effects that can impact patient outcomes.[1]The hemodynamic stability of patients undergoing IR procedures is a crucial consideration, as fluctuations in blood pressure, heart rate, and perfusion can affect procedural efficacy and patient safety. Hemodynamic stability is particularly relevant in patients with cardiovascular disease, coagulopathy, or other comorbidities that increase their vulnerability to anesthesia-induced changes in circulatory dynamics. GA, which involves the induction of unconsciousness, airway control, and mechanical ventilation, is traditionally used in more complex or prolonged interventions. However, it is associated with significant hemodynamic alterations, including hypotension, bradycardia, and the potential for myocardial depression due to anesthetic agents. Conversely, SA, which provides regional anesthesia by blocking nerve conduction in the spinal cord, has gained popularity in various surgical settings due to its ability to maintain spontaneous respiration, reduce postoperative nausea and vomiting, and decrease opioid requirements. Despite these advantages, SA also carries risks, such as profound hypotension due to sympathetic blockade and complications related to cerebrospinal fluid leakage.[2]The comparative effectiveness of SA versus GA in maintaining hemodynamic stability during IR procedures remains a subject of clinical interest. While GA offers the advantage of complete control over airway and ventilation, it can lead to greater fluctuations in hemodynamics due to the systemic effects of anesthetic drugs. Conversely, SA may provide better hemodynamic stability by avoiding airway manipulation and systemic anesthetic administration, yet it may also result in abrupt cardiovascular changes due to autonomic nervous system blockade. The extent to which these effects influence patient outcomes, procedure success, and recovery remains an area requiring further exploration.[3]In IR procedures, patient positioning is another factor that influences the choice of anesthesia. Some interventions require prolonged immobility in positions that may not be well tolerated under SA, necessitating the use of GA to ensure patient comfort and compliance. On the other hand, the ability of SA to reduce the need for systemic anesthetic agents may be particularly beneficial in patients with limited physiological reserves, such as those with compromised respiratory function or high anesthetic sensitivity. Thus, selecting the appropriate anesthetic technique requires a thorough evaluation of both patient-related and procedural factors.[4]Another critical aspect of anesthesia choice in IR is the impact on postoperative recovery and complications. GA is often associated with a higher incidence of postoperative nausea, respiratory depression, and delayed emergence, which can prolong hospital stays and recovery times. In contrast, SA has been shown to reduce the need for postoperative opioids, lower the risk of respiratory complications, and facilitate earlier ambulation. However, the potential for post-dural puncture headache, urinary retention, and prolonged hypotension must also be considered when opting for SA. Given these contrasting effects, a direct comparison of SA and GA in IR procedures is essential to determine which technique offers the best balance between hemodynamic stability, procedural efficacy, and patient safety.[5,6]The objective of this comparative study is to evaluate the hemodynamic stability of SA versus GA in patients undergoing IR procedures. By assessing key hemodynamic parameters such as blood pressure variability, heart rate fluctuations, and overall stability throughout the procedure, this study aims to provide insights into the advantages and limitations of each anesthetic approach. Furthermore, understanding the impact of anesthesia on patient outcomes, procedural efficiency, and recovery may guide anesthesiologists and interventional radiologists in optimizing anesthesia protocols for IR settings.

MATERIALS AND METHODS

This prospective comparative study was conducted to evaluate the hemodynamic stability of spinal anesthesia (SA) versus general anesthesia (GA) in patients undergoing interventional radiology procedures. The study was carried out at a tertiary care hospital following approval from the institutional ethics committee. Written informed consent was obtained from all participants before enrollment.

Patient Selection

A total of 110 patients scheduled for elective interventional radiology procedures were included in the study. Patients were allocated into two groups based on the anesthesia technique:

- **Spinal Anesthesia (SA) Group (n = 55):** Patients who underwent procedures under spinal anesthesia.
- **General Anesthesia (GA) Group (n = 55):** Patients who received general anesthesia.

Inclusion Criteria

- Adult patients (≥18 years) undergoing interventional radiology procedures requiring anesthesia.
- Hemodynamically stable patients at baseline.
- Patients classified as ASA (American Society of Anesthesiologists) physical status I-III.

Exclusion Criteria

- Patients with contraindications to spinal or general anesthesia (e.g., severe coagulopathy, spinal deformities, or significant cardiac instability).
- Known allergy to anesthetic agents.
- Patients with active infection at the injection site.

- Severe uncontrolled hypertension or arrhythmias.

Anesthetic Techniques

Spinal Anesthesia Protocol

Patients in the SA group received spinal anesthesia in a sterile environment using a 25G Quincke needle at the L3-L4 or L4-L5 intervertebral space. A total of 2.5-3.0 mL of hyperbaric bupivacaine (0.5%) was administered. Patients were positioned either in a sitting or lateral decubitus posture, depending on clinical feasibility. Hemodynamic parameters were closely monitored, and fluid preloading (500-1000 mL crystalloid) was administered to mitigate potential hypotension.

General Anesthesia Protocol

Patients in the GA group underwent standard induction with intravenous propofol (2 mg/kg), fentanyl (1-2 mcg/kg), and rocuronium (0.6 mg/kg) to facilitate endotracheal intubation. Anesthesia was maintained with sevoflurane (1-2 MAC) in a mixture of oxygen and air, with continuous hemodynamic monitoring. Reversal of neuromuscular blockade was achieved with neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg).

Hemodynamic Monitoring and Outcome Measures

Hemodynamic parameters, including heart rate (HR), mean arterial pressure (MAP), and oxygen saturation (SpO_2), were continuously monitored throughout the procedure and recorded at multiple time points. These included baseline measurements taken preoperatively, followed by readings at induction, and subsequently at 5, 10, 15, 30, and 60 minutes intraoperatively. Postoperative monitoring was conducted at the immediate recovery phase and further at 2, 6, and 24 hours to assess stability and recovery trends.

The primary outcomes of the study focused on the variations in HR and MAP between the spinal and general anesthesia groups, as well as the incidence of significant hemodynamic events, including hypotension, defined as a MAP drop of ≥20% from baseline, and bradycardia, characterized by HR <50 bpm. Secondary outcomes included the need for vasopressor support, such as ephedrine or phenylephrine, to maintain hemodynamic stability. Additionally, postoperative nausea and vomiting (PONV) incidence was documented, along with pain scores assessed using the Visual Analog Scale (VAS) at 1, 6, and 24 hours postoperatively. Recovery parameters, including total recovery time and length of hospital stay, were also evaluated to determine overall patient outcomes and anesthesia effectiveness.

Statistical Analysis

Statistical analysis was performed using SPSS version 22.0. Continuous variables were expressed as mean ± standard deviation (SD) and analyzed using an independent t-test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

RESULTS

Patient Demographics and ASA Classification

The demographic characteristics of the study population, including age, sex distribution, and ASA classification, were comparable between the spinal anesthesia (SA) and general anesthesia (GA) groups. The mean age of patients in the SA group was 52.34 ± 10.21 years, while in the GA group, it was 53.12 ± 9.87 years, with no significant difference (p = 0.654). The male-to-female ratio was also similar, with 60.00% males in the SA group and 58.18% in the GA group (p = 0.812), indicating a balanced gender distribution. ASA classification, which assesses preoperative physical status, was evenly distributed between groups, with 30.91% vs. 29.09% in ASA I, 50.91% vs. 49.09% in ASA II, and 18.18% vs. 21.82% in ASA III for the SA and GA groups, respectively. None of these differences were statistically significant (p > 0.05), confirming that both groups were well-matched in baseline characteristics.

Baseline Hemodynamic Parameters

The baseline hemodynamic parameters, including heart rate (HR), mean arterial pressure (MAP), and oxygen saturation (SpO_2), showed no significant difference between the two groups before anesthesia administration. The mean HR was 72.45 ± 5.23 bpm in the SA group and 74.82 ± 5.76 bpm in the GA group (p = 0.315), while the baseline MAP was 92.87 ± 6.12 mmHg and 94.35 ± 5.98 mmHg in the SA and GA groups, respectively (p = 0.289). Oxygen saturation levels were nearly identical, with 98.12 ± 1.24% in the SA group and 98.25 ± 1.18% in the GA group (p = 0.768). These results confirm that patients in both groups started the procedure with similar cardiovascular and respiratory conditions, allowing for a reliable comparison of intraoperative hemodynamic stability.

Intraoperative Hemodynamic Variability

Significant differences in intraoperative hemodynamics were observed between the two anesthesia techniques. HR and MAP were consistently lower in the SA group than in the GA group at all recorded time points. At induction, the mean HR in the SA group was 70.12 ± 4.87 bpm compared to 74.56 ± 5.14 bpm in the GA group (p = 0.042), with this trend persisting throughout the procedure. By the 60-minute mark, HR in the SA group had dropped to 66.34 ± 5.12 bpm, whereas it remained higher at 74.12 ± 5.42 bpm in the GA group (p = 0.031). Similarly, MAP followed a downward trend in the SA group, declining from 89.45 ± 5.67 mmHg at induction to 80.21 ± 6.41 mmHg at 30 minutes, before slightly stabilizing at 82.34 ± 6.23 mmHg at 60 minutes. In contrast, MAP in the GA group remained higher, ranging from 93.12 ± 5.98 mmHg at induction to 88.34 ± 6.12 mmHg at 60 minutes, with significant differences noted at multiple time points ($p < 0.05$). These findings suggest that spinal anesthesia leads to greater hemodynamic suppression compared to general anesthesia, requiring close monitoring and potential intervention to prevent excessive hypotension or bradycardia.

Incidence of Hemodynamic Events

The incidence of hemodynamic events differed between the two groups, with hypotension occurring more frequently in the SA group (30.91%) compared to the GA group (18.18%). However, this difference was not statistically significant (p = 0.085). Bradycardia was observed in 16.36% of patients under SA and in 10.91% of those under GA (p = 0.231), again showing a higher occurrence in the SA group but without statistical significance. Notably, vasopressor use was significantly greater in the SA group (25.45%) than in the GA group (12.73%) (p = 0.041), indicating that spinal anesthesia patients required more pharmacological support to maintain hemodynamic stability. This aligns with previous studies that have reported a higher likelihood of hypotension and bradycardia with neuraxial anesthesia due to sympathetic blockade.

Postoperative Outcomes

Postoperative pain scores, as measured by the Visual Analog Scale (VAS), were significantly lower in the SA group at all time points. At 1 hour postoperatively, the mean VAS score was 3.12 ± 1.02 in the SA group compared to 4.87 ± 1.23 in the GA group (p = 0.015). This trend continued at 6 hours (2.54 ± 1.12 vs. 3.76 ± 1.34, p = 0.022) and at 24 hours (1.87 ± 0.98 vs. 2.98 ± 1.12, p = 0.031), highlighting the superior postoperative analgesic effect of spinal anesthesia. The incidence of postoperative nausea and vomiting (PONV) was lower in the SA group (10.91%) compared to the GA group (21.82%) (p = 0.048), likely due to reduced opioid consumption and less exposure to volatile anesthetic agents. Recovery time was significantly shorter for the SA group (45.12 ± 5.34 minutes) versus the GA group (60.34 ± 6.12 minutes) (p = 0.009), demonstrating faster emergence and reduced post-anesthesia care unit (PACU) stay with spinal anesthesia. Hospital stay was also shorter in the SA group (2.87 ± 0.76 days) compared to the GA group (3.65 ± 0.89 days) (p = 0.027), suggesting that spinal anesthesia may contribute to faster overall recovery and earlier discharge.

Table 1: Patient Demographics and ASA Classification

Variable	Spinal Anesthesia (SA) (n=55)	General Anesthesia (GA) (n=55)	p-value
Age (years)	52.34 ± 10.21	53.12 ± 9.87	0.654
Male	33 (60.00%)	32 (58.18%)	0.812
Female	22 (40.00%)	23 (41.82%)	0.812
ASA I	17 (30.91%)	16 (29.09%)	0.768
ASA II	28 (50.91%)	27 (49.09%)	0.845
ASA III	10 (18.18%)	12 (21.82%)	0.625

Table 2: Baseline Hemodynamic Parameters

Parameter	Spinal Anesthesia (SA) (Mean ± SD)	General Anesthesia (GA) (Mean ± SD)	p-value
Heart Rate (bpm)	72.45 ± 5.23	74.82 ± 5.76	0.315
Mean Arterial Pressure (mmHg)	92.87 ± 6.12	94.35 ± 5.98	0.289
Oxygen Saturation (%)	98.12 ± 1.24	98.25 ± 1.18	0.768

Table 3: Intraoperative Hemodynamic Variability

Time Point	HR (SA) (Mean ± SD)	HR (GA) (Mean ± SD)	MAP (SA) (Mean ± SD)	MAP (GA) (Mean ± SD)	p-value
Induction	70.12 ± 4.87	74.56 ± 5.14	89.45 ± 5.67	93.12 ± 5.98	0.042*
5 min	68.95 ± 4.75	76.32 ± 5.27	85.12 ± 6.01	91.34 ± 5.76	0.018*
10 min	67.34 ± 5.01	77.12 ± 5.34	82.87 ± 6.23	90.45 ± 5.87	0.009*
15 min	66.12 ± 4.98	76.85 ± 5.21	81.54 ± 6.32	89.98 ± 6.02	0.012*
30 min	65.75 ± 5.23	75.34 ± 5.54	80.21 ± 6.41	89.12 ± 6.23	0.023*
60 min	66.34 ± 5.12	74.12 ± 5.42	82.34 ± 6.23	88.34 ± 6.12	0.031*

Table 4: Incidence of Hemodynamic Events

Event	Spinal Anesthesia (SA) (n=55)	General Anesthesia (GA) (n=55)	p-value
Hypotension (%)	17 (30.91%)	10 (18.18%)	0.085
Bradycardia (%)	9 (16.36%)	6 (10.91%)	0.231
Vasopressor Use (%)	14 (25.45%)	7 (12.73%)	0.041*

Table 5: Postoperative Outcomes

Outcome	Spinal Anesthesia (SA) (Mean ± SD or n (%))	General Anesthesia (GA) (Mean ± SD or n (%))	p-value
Pain Score (VAS) at 1h	3.12 ± 1.02	4.87 ± 1.23	0.015*
Pain Score (VAS) at 6h	2.54 ± 1.12	3.76 ± 1.34	0.022*
Pain Score (VAS) at 24h	1.87 ± 0.98	2.98 ± 1.12	0.031*
PONV (%)	6 (10.91%)	12 (21.82%)	0.048*
Recovery Time (min)	45.12 ± 5.34	60.34 ± 6.12	0.009*
Hospital Stay (days)	2.87 ± 0.76	3.65 ± 0.89	0.027*

DISCUSSION

In this comparative study of 110 patients undergoing interventional radiology procedures, we evaluated the hemodynamic stability and postoperative outcomes associated with spinal anesthesia (SA) and general anesthesia (GA).Our findings indicate that while SA is associated with greater intraoperative hemodynamic suppression, it offers superior postoperative pain control, reduced incidence of postoperative nausea and vomiting (PONV), shorter recovery times, and decreased hospital stays compared to GA.

Our study observed significant intraoperative hemodynamic differences between the anesthesia techniques.The SA group consistently exhibited lower heart rates (HR) and mean arterial pressures (MAP) at all recorded time points compared to the GA group.For instance, at induction, the SA group's mean HR was 70.12 ± 4.87 bpm versus 74.56 ± 5.14 bpm in the GA group ($p = 0.042$).Similarly, MAP decreased from 89.45 ± 5.67 mmHg at induction to 80.21 ± 6.41 mmHg at 30 minutes in the SA group, while the GA group maintained higher MAP levels ($p < 0.05$).These findings align with those of Ameli et al. (2019), who reported significant reductions in systolic and diastolic blood pressures under SA compared to GA.[7]Additionally, Rassouli et al. (2018) found that the incidence and severity of hypotension during cesarean sections under SA were comparable to those in healthy pregnant women, highlighting the hemodynamic effects of SA.[8]

In our study, hypotension occurred more frequently in the SA group (30.91%) than in the GA group (18.18%), though this difference was not statistically significant ($p = 0.085$).Bradycardia was observed in 16.36% of SA patients and 10.91% of GA patients ($p = 0.231$).Notably, vasopressor use was significantly higher in the SA group (25.45%) compared to the GA group (12.73%) ($p = 0.041$), indicating a greater need for pharmacological support to maintain hemodynamic stability under SA.These results are consistent with the findings of Mehrabi et al. (2017), who reported a higher likelihood of hypotension and bradycardia with neuraxial anesthesia due to sympathetic blockade.[9]Similarly, Tetzlaff et al. (2014) demonstrated that SA was associated with lower side effects compared to GA in spinal surgeries, further supporting our observations.[10]

Our study demonstrated that SA provided superior postoperative analgesia, with significantly lower Visual Analog Scale (VAS) pain scores at all assessed time points.At 1 hour postoperatively, the SA group's mean VAS score was 3.12 ± 1.02, compared to 4.87 ± 1.23 in the GA group ($p = 0.015$).This trend persisted at 6 and 24 hours postoperatively ($p < 0.05$).Additionally, the incidence of PONV was significantly lower in the SA group (10.91%) compared to the GA group (21.82%) ($p = 0.048$).These findings are in line with those of McClain et al. (2015), who reported reduced postoperative analgesic consumption in patients receiving SA.[11]Furthermore, a meta-analysis by Pumberger et al. (2018) found that GA patients were five times more likely to develop PONV compared to SA patients, corroborating our results.[12]

Recovery times were significantly shorter for the SA group, with an average of 45.12 ± 5.34 minutes compared to 60.34 ± 6.12 minutes in the GA group ($p = 0.009$).Hospital stays were also reduced in the SA group, averaging 2.87 ± 0.76 days versus 3.65 ± 0.89 days in the GA group ($p = 0.027$).These outcomes are consistent with the findings of Tzimas et al. (2018), who reported shorter hospital stays and faster recovery times associated with SA.[13]Similarly, a study by Neuman et al. (2017) demonstrated increased use of SA for hip fracture repairs, associated with favorable postoperative outcomes, supporting our observations.[14]

CONCLUSION

In conclusion, this study demonstrates that spinal anesthesia (SA) provides superior postoperative analgesia, reduced incidence of postoperative nausea and vomiting (PONV), shorter recovery times, and a decreased length of hospital stay compared to general anesthesia (GA) in patients undergoing interventional radiology procedures. However, SA is associated with greater intraoperative hemodynamic suppression, requiring more vasopressor support. Overall, SA may be the preferred option in patients where enhanced recovery and pain control are prioritized, but careful monitoring is essential to mitigate potential hemodynamic complications.

REFERENCES

1. Neuman MD, Feng R, Carson JL, et al. Spinal Anesthesia or General Anesthesia for Hip Surgery in Older Adults. N Engl J Med. 2021;385(22):2025-2035.
2. Pugely AJ, Martin CT, Gao Y, et al. Differences in short-term complications between spinal and general

anesthesia for primary total knee arthroplasty. J Bone Joint Surg Am. 2013;95(3):193-9.
3. Johnson RL, Kopp SL, Burkle CM, et al. Neuraxial vs general anaesthesia for total hip and total knee arthroplasty: a systematic review of comparative-effectiveness research. Br J Anaesth. 2016;116(2):163-76.
4. Memtsoudis SG, Cozowicz C, Bekeris J, et al. Anaesthetic care of patients undergoing primary hip and knee arthroplasty: consensus recommendations from the International Consensus on Anaesthesia-Related Outcomes after Surgery group (ICAROS) based on a systematic review and meta-analysis. Br J Anaesth. 2019;123(3):269-287
5. Zhao J, Zhang Y, Chen X, et al. Effects of spinal anesthesia versus general anesthesia on postoperative outcomes in elderly patients undergoing hip fracture surgery: A meta-analysis. *J Clin Anesth.*2017;38:95-103.
6. Wang X, Xie L, Chen L, et al. Comparison of spinal anesthesia and general anesthesia for laparoscopic colorectal surgery: A meta-analysis of randomized controlled trials. *Int J Surg.*2017;44:36-44.
7. Ameli S, Shayeghi S, Yazdi B, et al. Incremental dosing versus single-dose spinal anesthesia: hemodynamic effects in elderly patients. AnesthAnalg. 2019;129(5):1429-1435.
8. Rassouli F, Zahiri Z, Beigi NM, et al. Prevention of hypotension after spinal anesthesia for cesarean section: a systematic review and meta-analysis. Int J ObstetAnesth. 2018;36:64-79.
9. Mehrabi S, Jafarzadeh A, Rezaei M, et al. Hemodynamic effects of spinal anesthesia in the elderly: single dose versus titration through a catheter. AnesthAnalg. 2017;124(4):1102-1109.
10. Tetzlaff JE, Dilger JA, Kodsy M, et al. Spinal anesthesia for elective surgery: a comparison of side effects and recovery profiles in spinal versus general anesthesia. J Clin Anesth. 2014;26(6):456-461.
11. McClain RL, McKinney B, Horn JL, et al. Postoperative analgesia: a comparison of continuous spinal anesthesia versus general anesthesia. Pain Med. 2015;16(1):121-128.
12. Pumberger M, Memtsoudis SG, Stundner O, et al. Anesthesia and postoperative outcomes after hip fracture surgery: a retrospective matched cohort study. Medicine (Baltimore). 2018;97(26):e11426.
13. Tzimas P, Samara E, Petrou A, et al. The influence of anesthetic technique on postoperative cognitive function in elderly patients undergoing hip fracture surgery: general vs spinal anesthesia. Injury. 2018;49(12):2221-2226.
14. Neuman MD, Silber JH, Elkassabany NM, et al. Comparative effectiveness of regional versus general anesthesia for hip fracture surgery in adults. Anesthesiology. 2017;