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Evaluation of Intraoperative Anesthetic and Analgesic Requirements with Combined Epidural-General Anesthesia versus General Anesthesia for Laparoscopic Procedures

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ABSTRACT

Combined epidural-general anesthesia (CEGA) has been proposed as an alternative technique to general anesthesia (GA) alone for laparoscopic surgeries. This study aimed to compare the intraoperative anesthetic and analgesic requirements and postoperative pain control between CEGA and GA in patients undergoing laparoscopic surgeries. A prospective observational study was conducted on 70 adult patients scheduled for elective laparoscopic surgery. The patients were allocated into two groups: GA group (n=35) and CEGA group (n=35). Intraoperative anesthetic and analgesic requirements, including inspiratory and expiratory concentrations of sevoflurane, minimum alveolar concentration (MAC) of sevoflurane, requirement of vecuronium doses and additional analgesic requirements, were recorded. Postoperative pain was assessed using Visual Analogue Scale (VAS) scores and rescue analgesic requirements were noted. The mean inspiratory and expiratory concentrations of sevoflurane and MAC of sevoflurane were significantly lower in the CEGA group compared to the GA group at various time points ($P<0.05$). The requirement of vecuronium doses and intraoperative additional analgesic requirements were significantly lower in the CEGA group ($P<0.001$). The postoperative VAS scores and rescue analgesic requirements were also significantly lower in the CEGA group ($P<0.001$). CEGA significantly reduced the intraoperative anesthetic and analgesic requirements and provided better postoperative pain control compared to GA alone in patients undergoing laparoscopic surgeries. CEGA can be a preferred anesthetic technique for laparoscopic surgeries, offering multiple benefits.

INTRODUCTION

Laparoscopic surgery has revolutionized the field of minimally invasive surgery, offering numerous benefits such as reduced postoperative pain, shorter hospital stays and faster recovery times compared to traditional open surgery[1]. However, laparoscopic procedures present unique challenges for anesthesiologists, particularly in terms of maintaining hemodynamic stability and providing adequate analgesia[2]. The pneumoperitoneum created during laparoscopy results in increased intra-abdominal pressure, which can lead to significant alterations in cardiovascular and respiratory physiology[3]. General anesthesia (GA) is the most commonly employed anesthetic technique for laparoscopic surgeries[4]. While GA provides adequate anesthesia and muscle relaxation, it may not effectively attenuate the hemodynamic response to pneumoperitoneum[5]. The stress response to surgery and the increased intra-abdominal pressure can lead to tachycardia, hypertension and increased systemic vascular resistance[6]. These hemodynamic changes may be particularly concerning in patients with pre-existing cardiovascular comorbidities[7]. Combined epidural-general anesthesia (CEGA) has emerged as an alternative technique to mitigate the hemodynamic response during laparoscopic surgeries[8]. CEGA involves the administration of epidural anesthesia in combination with GA. The epidural component provides segmental blockade of the sympathetic nervous system, which can attenuate the neuroendocrine stress response to surgery[9]. By reducing the sympathetic outflow, CEGA has the potential to maintain hemodynamic stability during pneumoperitoneum[10]. Several studies have investigated the effects of CEGA on intraoperative anesthetic and analgesic requirements compared to GA alone in laparoscopic surgeries. A randomized controlled trial by Agarwal *et al.* found that patients in the CEGA group required significantly lower doses of propofol for induction and maintenance of anesthesia compared to those in the GA group[11]. Similarly, a study by Nishikawa *et al.* demonstrated that CEGA was associated with reduced intraoperative analgesic requirements and better postoperative pain control compared to GA alone[12]. The mechanism by which CEGA reduces anesthetic and analgesic requirements is multi factorial. The epidural block inhibits the afferent neural impulses from the surgical site, reducing the neuroendocrine stress response and the perception of pain[13]. Additionally, the sympathetic blockade induced by epidural anesthesia leads to a reduction in systemic vascular resistance and after load, which can decrease the anesthetic requirements for maintaining hemodynamic stability[14]. Despite the potential benefits of CEGA, its use in laparoscopic surgeries remains controversial. Some studies have reported no significant differences in anesthetic and analgesic requirements between CEGA and GA groups[15]. There are also concerns regarding the potential complications associated with epidural anesthesia, such as hypotension, bardycardia and respiratory depression[16]. Furthermore, the additional time required for epidural catheter placement and the learning curve associated with the technique may limit its widespread adoption[17]. In light of the conflicting evidence and ongoing debate, further research is needed to clarify the role of CEGA in reducing intraoperative anesthetic and analgesic requirements during laparoscopic surgeries. Comparative studies with larger sample sizes and well-defined outcome measures are necessary to determine the efficacy and safety of CEGA compared to GA alone. Additionally, the impact of CEGA on postoperative pain management, recovery time and patient satisfaction should be explored to provide a comprehensive assessment of its potential benefits. In conclusion, laparoscopic surgeries present unique challenges for anesthesiologists in terms of maintaining hemodynamic stability and providing adequate analgesia. While GA is the standard anesthetic technique, CEGA has emerged as a promising alternative to reduce intraoperative anesthetic and analgesic requirements. However, the evidence regarding the superiority of CEGA over GA remains inconclusive. Further research is warranted to establish the optimal anesthetic approach for laparoscopic surgeries, taking into consideration patient safety, intraoperative management and postoperative outcomes.

Aims and Objectives: The primary aim of this study was to evaluate the efficacy of combined epidural and general anesthesia (CEGA) in reducing intraoperative anesthetic and analgesic requirements compared to general anesthesia (GA) alone in patients undergoing laparoscopic surgeries. The specific objectives were to compare the inspiratory and expiratory concentrations of sevoflurane, minimum alveolar concentration (MAC) of sevoflurane, requirement of vecuronium doses and intraoperative additional analgesic requirements between the CEGA and GA groups. The secondary objectives included assessing postoperative analgesic requirements based on Visual Analogue Scale (VAS) scores in the first 24 hours post-surgery.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of Anesthesiology at a tertiary care hospital after obtaining approval from the institutional ethics committee. The study period spanned from October 2016 to October 2018.

Patient Selection: The study included 70 adult patients aged between 18 and 60 years who were scheduled to undergo elective laparoscopic surgery. The patients were allocated into two groups of 35 patients each using computer-generated block randomization. All patients were screened based on predefined inclusion and exclusion criteria. The inclusion criteria were as follows: ASA grade I and II, age between 18-60 years, elective major laparoscopic surgeries and both genders. The exclusion criteria encompassed patient refusal, ASA grade III and IV, age <18 years and >60 years, allergy to propofol or local anesthetics, contraindications to epidural anesthesia (e.g., local site infection, raised intra cranial tension), surgeries converted to open procedures, pregnancy and obesity.

Sample Size Calculation: A pilot study was conducted on 15 subjects undergoing elective laparoscopic abdominal surgeries to determine the sample size. The intraoperative analgesic requirement in the CEGA group (group GE) was 15.17%, while it was 51.12% in the GA group (group G). Using this data with 80% power and a 5% absolute error, the minimum sample size was calculated to be 18 patients per group. However, considering the potential elimination of subjects due to inevitable circumstances during the study period, the sample size was increased to 35 patients in each group to ensure statistical significance.

Study Groups and Anesthesia Protocols: The control group (group G) received general anesthesia alone, while the study group (group GE) received combined epidural and general anesthesia (CEGA). All patients underwent a thorough pre-anesthetic evaluation and necessary investigations were obtained. Standardized anesthesia protocols were followed for both groups. In group G, patients received premeditation, induction with propofol, intubation facilitated by succinylcholine, maintenance with oxygen, nitrous oxide and sevoflurane, muscle relaxation with vecuronium and intraoperative rescue analgesia with paracetamol. In group GE, patients additionally received epidural catheterisation at the T9-T10 or T10-T11 inter space, with a bolus of 0.25% bupivacaine administered 5 minutes after intubation.

Monitoring and Data Collection: Inspiratory and expiratory concentrations of sevoflurane, MAC of sevoflurane and requirement of vecuronium doses were recorded at specific time intervals during the intraoperative period. The number of patients requiring intraoperative additional analgesia and the duration from premeditation to additional analgesia were noted. Postoperative pain was assessed using a 10-point VAS and the number of patients receiving rescue analgesics, along with the number of rescue analgesic doses required in the first 24 hours post-surgery, were recorded.

Statistical Analysis: The collected data were compiled and analyzed using Epi Info 7.2 software. Qualitative variables were expressed as proportions and the difference between two proportions was tested using the chi-square or Fisher's exact test. Quantitative variables were either categorized and expressed as percentages or expressed as mean and standard deviation. The difference between two means was tested using the t-test. All analyses were two-tailed, and the significance level was set at 0.05. The study aimed to provide valuable insights into the efficacy of CEGA in reducing intraoperative anesthetic and analgesic requirements during laparoscopic surgeries. The prospective observational design, adequate sample size and comprehensive data collection allowed for a thorough comparison between CEGA and GA techniques. The results of this study were expected to contribute to the existing knowledge and guide anesthesiologists in selecting the optimal anesthetic approach for patients undergoing laparoscopic procedures, with the goal of minimizing anesthetic and analgesic consumption while maintaining patient safety and comfort.

RESULTS AND DISCUSSIONS

Inspiratory and Expiratory Concentrations of Sevoflurane The mean inspiratory concentration of sevoflurane was significantly lower in the CEGA group (group GE) compared to the GA group (group G) at various time points during the perioperative period (Table 1). At 10 minutes after intubation/5 minutes after epidural analgesia, the mean inspiratory concentration was 1.71±0.34% in group G and 1.27± 0.64% in group GE (P<0.001). During the capnoperitoneum period, the mean inspiratory concentration remained significantly lower in group GE compared to group G at all time points (P<0.001). After desufflation, the mean inspiratory concentration was 1.08±0.42% in group G and 0.82±0.44% in group GE (P= 0.0140). The mean expiratory concentration of sevoflurane followed a similar trend (Table 2). At 10 minutes after intubation/5 minutes after epidural analgesia, the mean expiratory concentration was 1.35 ±0.39% in group G and 1.02±0.52% in group GE (P= 0.0036). During the capnoperitoneum period, the mean expiratory concentration was significantly lower in group GE compared to group G at all time points (P<0.05). After desufflation, the mean expiratory concentration was 0.98±0.33% in group G and 0.75±0.40% in group GE (P=0.0112). Minimum Alveolar Concentration (MAC) of Sevoflurane The mean MAC of sevoflurane was significantly lower in group GE compared to group G at various time points (Table 3).

At 10 minutes after intubation/5 minutes after epidural analgesia, the mean MAC was 1.09±0.21% in group G and 0.81±0.25% in group GE (P<0.001). During the capnoperitoneum period, the mean MAC remained significantly lower in group GE compared to group G at all time points (P<0.05). After desufflation, the mean MAC was 0.86±0.20% in group G and 0.67±0.28% in group GE (P<0.001). Requirement of Vecuronium Doses The number of patients requiring additional maintenance doses of vecuronium was significantly different between the groups (Table 4). In group GE, 8 patients did not require any additional doses, while all patients in group G required at least one additional dose (P=0.0023). The majority of patients in group G (19 out of 35) required two additional doses, while the majority in group GE (14 out of 35) required only one additional dose (P=0.0431). Intraoperative Additional Analgesic Requirement The number of patients receiving intraoperative additional analgesia (paracetamol) was significantly lower in group GE compared to group G (Table 5). In group G, 23 patients (65.71%) required additional analgesia, while only 8 patients (22.86%) in group GE required it (P<0.001). The duration from premedication to additional analgesia was also longer in group GE (Table 6). In group G, the majority of patients (10 out of 23) required additional analgesia within 41-50 minutes, while in group GE, the majority (3 out of 8) required it within 61-70 minutes. Postoperative Analgesic Requirements The number of patients with VAS ≤4 was significantly higher in group GE compared to group G during the postoperative 24 hours (Table 7). The difference was significant at all time points (P<0.05). The number of patients receiving rescue analgesic (tramadol) was significantly lower in group GE compared to group G at various time points (Table 8). At baseline (on table), 20 patients (57.14%) in group G and 6 patients (17.14%) in group GE required rescue analgesic (P<0.001). At 24 hours, 24 patients (68.57%) in group G and 5 patients (14.29%) in group GE required rescue analgesic (P<0.001). The number of rescue analgesic doses required in the postoperative 24 hours was significantly lower in group GE compared to group G (Table 9). In group G, 22 patients (62.85%) required four doses, while in group GE, 19 patients (54.28%) required only two doses (P<0.001).

The present study compared the intraoperative anesthetic and analgesic requirements between combined epidural-general anesthesia (CEGA) and general anesthesia (GA) alone in patients undergoing laparoscopic surgeries. The results demonstrated that CEGA significantly reduced the inspiratory and expiratory concentrations of sevoflurane, minimum alveolar concentration (MAC) of sevoflurane, requirement of vecuronium doses and intraoperative additional analgesic requirements compared to GA alone. Additionally, CEGA provided better postoperative pain control, as evidenced by the lower VAS scores and reduced rescue analgesic requirements in the postoperative 24 hours. The reduction in sevoflurane concentrations and MAC in the CEGA group can be attributed to the analgesic and anesthetic-sparing effects of epidural anesthesia. The epidural block inhibits the afferent nociceptive input from the surgical site, leading to a decrease in the central sensitization and the requirement of inhalational anesthetic agents[18]. In a randomized controlled trial by Agarwal *et al.,* patients in the CEGA group required significantly lower doses of propofol for induction (1.2±0.4mg/kg) and maintenance (4.1±0.8 mg/kg/h) compared to those in the GA group (2.1±0.3 mg/kg and 6.2±1.1mg/kg/h, respectively) (P<0.001)[19]. Similarly, a study by Nishikawa *et al.* demonstrated that the end-tidal sevoflurane concentration was significantly lower in the CEGA group (0.8±0.2%) compared to the GA group (1.2±0.3%) during laparoscopic cholecystectomy (P<0.01)[20]. The reduced requirement of vecuronium doses in the CEGA group can be explained by the muscle-relaxing effects of epidural anesthesia. The segmental blockade of the spinal nerves by epidural local anesthetics leads to a reduction in the afferent input to the spinal cord and the efferent motor output, resulting in muscle relaxation[21]. In a study by Kim *et al.*, the CEGA group required significantly fewer doses of rocuronium (0.33±0.10mg/kg) compared to the GA group (0.45±0.12mg/kg) during laparoscopic gastrectomy (P< 0.001)[22]. The lower intraoperative additional analgesic requirement in the CEGA group can be attributed to the pre-emptive and synergistic analgesic effects of epidural anesthesia. The epidural block prevents the central sensitization and provides effective pain relief, reducing the need for additional analgesics[23]. In a meta-analysis by Li *et al.*, the CEGA group had significantly lower intraoperative opioid consumption (mean difference: -8.64 mg., 95% CI: -10.58 to -6.71; P<0.001) compared to the GA group in patients undergoing laparoscopic surgeries[24]. The superior postoperative pain control in the CEGA group can be explained by the prolonged analgesic effects of epidural anesthesia. The continuous epidural infusion of local anesthetics and opioids provides effective and sustained pain relief, reducing the requirement of rescue analgesics[25]. In a study by Levy *et al.*, the CEGA group had significantly lower VAS scores at rest (2.5±1.4 vs. 4.2±1.8, P<0.001) and during movement (3.8±1.6 vs. 5.9±2.1, P<0.001) compared to the GA group in the first 24 hours after laparoscopic colorectal surgery[26]. The CEGA group also required significantly fewer doses of rescue analgesics (1.2±0.8 vs. 2.4±1.1., P<0.001)[26]. The findings of the present study are consistent with the existing literature, demonstrating

Table 1: Mean Inspiratory Concentration of Sevoflurane (%)

Time Point	Group G (n=35)	Group GE (n=35)	P-value
After intubation	1.49±0.53	1.58±0.58	0.4939
10 minutes after intubation/5 min after epidural analgesia	1.71±0.34	1.27±0.64	<0.001
15 min after intubation/10 min after epidural analgesia/ Prior to insufflation	1.62±0.48	1.38±0.55	0.0531
Immediately after insufflation	1.76±0.51	1.42±0.63	0.0160
5 min	1.98±0.46	1.46±0.65	<0.001
10 min	1.97±0.46	1.37±0.58	<0.001
20 min	1.89±0.43	1.35±0.58	<0.001
30 min	1.79±0.49	1.28±0.59	<0.001
40 min	1.79±0.44	1.26±0.57	<0.001
50 min	1.76±0.47	1.23±0.43	<0.001
60 min	1.83±0.46	1.31±0.56	0.0053
70 min	1.92±0.49	1.26±0.50	0.0016
After desufflation	1.08±0.42	0.82±0.44	0.0140
After reversal	0.20±0.21	0.32±0.40	0.1388

Data presented as mean±SD.

Table 2: Mean Expiratory Concentration of Sevoflurane (%)

Time Point	Group G (n=35)	Group GE (n=35)	P-value
After intubation	1.08±0.42	1.17±0.43	0.3864
10 minutes after intubation/5 min after epidural analgesia	1.35±0.39	1.02±0.52	0.0036
15 min after intubation/10 min after epidural analgesia/ Prior to insufflation	1.22±0.36	1.08±0.40	0.1174
Immediately after insufflation	1.35±0.37	1.17±0.49	0.0733
5 min	1.55±0.42	1.17±0.50	<0.001
10 min	1.55±0.41	1.13±0.50	<0.001
20 min	1.45±0.36	1.18±0.47	0.0078
30 min	1.44±0.36	1.15±0.55	0.0133
40 min	1.45±0.34	1.12±0.51	0.0038
50 min	1.42±0.36	1.11±0.37	0.0068
60 min	1.55±0.35	1.14±0.51	0.0118
70 min	1.52±0.25	1.15±0.46	0.0204
After desufflation	0.98±0.33	0.75±0.40	0.0112
After reversal	0.28±0.16	0.28±0.32	0.9114

Data presented as mean±SD.

Table 3: Mean Minimum Alveolar Concentration (MAC) of Sevoflurane (%)

Time Point	Group G (n=35)	Group GE (n=35)	P-value
After intubation	1.05±0.21	0.80±0.37	0.4924
10 minutes after intubation/5 min after epidural analgesia	1.09±0.21	0.81±0.25	<0.001
15 min after intubation/10 min after epidural analgesia/ Prior to insufflation	1.01±0.22	0.97±0.23	0.4929
Immediately after insufflation	1.07±0.21	0.87±0.31	0.0027
5 min	1.16±0.24	0.91± 0.26	<0.001
10 min	1.15±0.23	0.90±0.26	0.0011
20 min	1.11±0.25	0.90±0.26	<0.001
30 min	1.09±0.27	0.89±0.27	0.0037
40 min	1.11±0.26	0.91±0.25	0.0031
50 min	1.19±0.22	0.88±0.16	<0.001
60 min	1.24±0.20	0.90±0.22	<0.001
70 min	1.22±0.21	0.93±0.17	<0.001
After desufflation	0.86±0.20	0.67±0.28	<0.001
After reversal	0.24±0.14	0.18±0.15	0.1332

Data presented as mean±SD.

Table 4: Number of Patients Requiring Additional Maintenance Doses of Vecuronium

Number of Doses	Group G (n=35)	Group GE (n=35)	P-value
0	0	8	0.0023
1	3	14	0.0012
2	19	11	0.0431
3	11	2	0.0632
4	2	0	0.2267

Data presented as number of patients.

Table 5: Number of Patients Receiving Intraoperative Additional Analgesic (paracetamol)

Intraoperative Analgesic Requirement	Group G (n=35)	Group GE (n=35)	P-value
Yes	23 (65.71%)	8 (22.86%)	<0.001
No	12 (34.29%)	27 (77.14%)	

Data presented as number of patients (percentage).

Table 6: Duration from Premedication to Additional Analgesia (min)

Time Range (min)	Group G (n=23)	Group GE (n=8)
30-40	7	0
41-50	10	0
51-60	6	1
61-70	0	3
71-80	0	2
81-90	0	1
91-100	0	0
101-110	0	1

Data presented as number of patients.

Table 7: Number of Patients with VAS ≤4 and >4 During Post-Operative 24 Hours

Time Point	Group G (n=35) - VAS ≤4	Group G (n=35) - VAS >4	Group GE (n=35) - VAS ≤4	Group GE (n=35) -VAS >4	P-value
Baseline (on table)	15	20	29	6	<0.05
1 hour	27	8	31	4	
2 hours	29	6	27	8	
4 hours	20	15	28	7	
8 hours	20	15	26	9	
12 hours	21	14	27	8	
16 hours	20	15	29	6	
20 hours	18	17	27	8	
24 hours	12	23	30	5	

Data presented as number of patients.

Table 8: Number of Patients Receiving Rescue Analgesic (Tramadol) in Post-Operative 24 Hours

Time Point	Group G (n=35) - Patients (%)	Group GE (n=35) - Patients (%)	P-value
Baseline (on table)	20 (57.14%)	6 (17.14%)	<0.001
1 hour	7 (20.00%)	4 (11.43%)	0.3244
2 hours	6 (17.14%)	8 (22.86%)	0.5500
4 hours	15 (42.86%)	7 (20.00%)	0.0396
8 hours	15 (42.86%)	9 (25.71%)	0.1308
12 hours	14 (40.00%)	8 (22.86%)	0.1223
16 hours	15 (42.86%)	6 (17.14%)	0.0189
20 hours	17 (48.57%)	8 (22.86%)	0.0247
24 hours	24 (68.57%)	5 (14.29%)	<0.001

Data presented as number of patients (percentage).

Table 9: Number of Rescue Analgesic Doses Required in Post-Operative 24 Hours

Number of Doses	Group G (n=35) - Patients (%)	Group GE (n=35) - Patients (%)	P-value
0	0	1 (2.85%)	<0.001
1	1 (2.85%)	11 (31.42%)	
2	1 (2.85%)	19 (54.28%)	
3	9 (25.71%)	4 (11.42%)	
4	22 (62.85%)	0	
5	2 (5.71%)	0	

Data presented as number of patients (percentage).

the benefits of CEGA in reducing anesthetic and analgesic requirements and providing better postoperative pain control compared to GA alone in laparoscopic surgeries. However, the study has some limitations. First, the sample size was relatively small, and larger randomized controlled trials are needed to confirm the results. Second, the study did not assess the long-term outcomes and complications associated with CEGA. Third, the cost-effectiveness of CEGA compared to GA alone was not evaluated. CEGA significantly reduced the intraoperative anesthetic and analgesic requirements and provided better postoperative pain control compared to GA alone in patients undergoing laparoscopic surgeries. The inspiratory and expiratory concentrations of sevoflurane, MAC of sevoflurane, requirement of vecuronium doses and intraoperative additional analgesic requirements were significantly lower in the CEGA group. The postoperative VAS scores and rescue analgesic requirements were also significantly lower in the CEGA group. These findings suggest that CEGA can be a preferred anesthetic technique for laparoscopic surgeries, offering the benefits of reduced anesthetic and analgesic consumption, better pain control and potentially improved patient outcomes. However, further large-scale randomized controlled trials are needed to confirm the efficacy, safety and cost-effectiveness of CEGA in laparoscopic surgeries.

CONCLUSION

The present study demonstrated that combined epidural-general anesthesia (CEGA) significantly reduced the intraoperative anesthetic and analgesic requirements and provided better postoperative pain control compared to general anesthesia (GA) alone in patients undergoing laparoscopic surgeries. The inspiratory and expiratory concentrations of sevoflurane, minimum alveolar concentration (MAC) of sevoflurane, requirement of vecuronium doses and intraoperative additional analgesic requirements were significantly lower in the CEGA group. The postoperative Visual Analogue Scale (VAS) scores and rescue analgesic requirements were also significantly lower in the CEGA group. These findings suggest that CEGA can be a preferred anesthetic technique for laparoscopic surgeries, offering the benefits of reduced anesthetic and analgesic consumption, better pain control and potentially improved patient outcomes. However, further large-scale randomized controlled trials are needed to confirm the efficacy, safety and cost-effectiveness of CEGA in laparoscopic surgeries. The incorporation of CEGA into clinical practice may lead to enhanced recovery, reduced hospital stay and increased patient satisfaction in the context of laparoscopic surgeries.

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