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RESEARCH ARTICLE

EVALUATION OF THE EFFECTIVENESS OF POSTOPERATIVE ANALGESIA AFTER MAJOR ABDOMINAL SURGERY

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Abstract

Background: Postoperative pain (PP) relief improves patient comfort, facilitates recovery, reduce length of hospital stay (LOS) and chronic pain. The complexity of PP in major abdominal surgery (MAS) is an indication for the use of multimodal analgesia (MA).

Aim: To evaluate the effectiveness of different methods of postoperative analgesia in patients undergoing MAS.

Method and Mattwerial: A prospective, comparative observational study was conducted. The study population was all patients who underwent elective MAS between September 2019 and July 2023, in a general public hospital in Attica. Patients were divided into three groups based on analgesia: a) Group A: analgesia via an epidural catheter in the lumbar or thoracic region. b) Group B: analgesia with continuous wound infusion of anesthetic with an On-Q system c) Group C: iv analgesia. Patients of B and C groups also received patient controlled analgesic morphine (PCA). The effectiveness of analgesia was assessed at rest and cough by the numerical rate scale (NRS) and morphine consumption. In addition, blood pressure, oxygenation status, vomiting, recovery of bowel function and the LOS were recorded. The statistical program SPSS 26.0 was used for the analysis.

Results: The study sample consisted of 89 adult patients who underwent planned MAS and were allocated to the analgesia groups [Group A N=44(49.4%), Group B N=30(33.7%), Group C N=15 (16.9%)]. The mean age of the sample was 62.7 years (SD=17.8 years). The pain score in Group A was significantly higher compared to Group B throughout the follow-up period. Rest pain decreased over time in all three analgesia groups ($p<0.001$ for A, $p<0.001$ for B and $p=0.001$ for C). However, the degree of reduction differed significantly between the 3 groups, $p=0.013$. The mean systolic blood pressure was significantly higher on the 1st postoperative day in Group C compared to both Group A and Group B.

Conclusions: Continuous wound infusion analgesia with On-Q pump as a component of MA was more effective in the management of acute PP in patients with MAS than epidural and intravenous MA. It also reduces overall opioid consumption and can be a safe and effective alternative solution in the management of acute PP in patients with MAS.

Key words: Postoperative multimodal analgesia, pain management, major abdominal surgery, continuous wound infusion, epidural analgesia, intravenous analgesia, patient-controlled analgesia.

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INTRODUCTION

Major abdominal surgery (MAS) encompasses a broad range of surgical procedures in a heterogeneous population, with common feature the laparotomy, which is accompanied by severe postoperative pain (PP). Extensive surgical incisions and "injuries" to both superficial and deep tissues and/or organs are the most important cause of acute postoperative pain, which worsens by coughing, deep breathing, changing position in bed and mobilization, actions that also contribute to the prevention of complications and faster recovery after surgery. [1,2,3] Despite of international recommendations for management of postoperative pain and the availability of pharmaceutical and non-pharmacological methods, no significant improvements have been recorded and inadequate treatment of postoperative pain continues to be a significant problem worldwide.[1,4] Ineffective management of PP has been associated with increased morbidity and mortality[5,6,7] as well as reduced patient satisfaction.[5] In addition, the progression of acute PP to chronic can affect the patient's quality of life and daily activities and lead to physical disability.[5,6]

The Enhanced Recovery After Surgery (ERAS) Society provides guidelines for better recovery and reduction of postoperative complications for abdominal procedures. [8] The complexity of PP in MAS is an indication for the use of multimodal analgesia. Multimodal analgesia using different analgesic agents and techniques aims to control pain through different mechanisms. There are many analgesic options that include different pharmaceutical agents and routes of administration.[1] Paracetamol, non-steroidal anti-inflammatory drugs (NSAIDs) in combination with opioids constitute the recommended multimodal analgesia, despite the fact that associates them with postoperative complications and adverse effects.[8] Opioids remain the mainstay of PP management, while epidural analgesia (EA) is the gold standard for MAS.[9] However, serious opioid related side-effects[10,11] and complications from epidural analgesia, such as hypotension, epidural hematoma and increased failure rates[12] have led to new analgesic techniques. [13] However, evidence had failed to lead to any clear conclusion as to which technique other than epidural is equally effective and safe in the management of PP. [14] Nurses have a professional and ethical responsibility to ensure effective pain relief.[8, 15] Newer approaches to pain management focus on multimodal pain management with the involvement of pain specialists, which plays an important role in the nursing care process. They also promote techniques that contribute in reducing the use of opioids as much as possible.

AIM

The aim of the present study was to evaluate the effectiveness of postoperative analgesia in patients undergoing major abdominal surgery.

METHODOLOGY

Study design

This was a prospective comparative observational study, which approved by the Institutional Committee for the Protection of Human Subjects in Biomedical Research of tertiary level hospital, in Attica, Greece (4389/9-10-2020). Written informed consent was obtained from all participants.

Study population

The study population consisted of all patients who underwent elective MAS during the period of October 2020 - July 2023. MAS was defined as procedures such as exploratory laparotomy, gastrectomy, bariatric surgery, pancreatectomy, cholecystectomy, splenectomy, surgical procedures (resections) of the rectum, colon and small intestine, cystectomy, nephrectomy and hysterectomy. The inclusion criteria were: patients > 18 years old, who both understand and speak the Greek language. The exclusion criteria included postoperative sedation, inability to communicate (e.g. deaf-mute), history of chronic pain under drugs affecting the central nervous system (benzodiazepines, barbiturates, and opioids) and a history of allergy to local anesthetics. Patients with history of chronic diseases such as: liver or kidney disease, dementia, mental and psychiatric disorders were also excluded. A total of 95 patients were invited to participate in this study. Nighty two consented to participate and complete the questionnaire (response rate (96.8%). Finally, 89 patients were enrolled in the study as 3 were excluded due to incomplete data recording in the questionnaire.

Study protocol

Patients were divided into 3 groups: Patients of the first group (Group A= EA), received epidural analgesia by a catheter which placed in the lumbar or thoracic part of the spinal cord. Titrated doses of ropivacaine and morphine were administered 45-60 minutes before the end of the operation. After the end of the operation, titrated doses of ropivacaine and morphine were administered postoperatively at intervals of 8-10 hours. The patients of the second group (Group B=On-Q), received a postoperative continuous surgical site analgesia with an On-Q pump. Two antimicrobial silver-plated On-Q Silver Soaker multiholed catheters, 12.5 cm or 19 cm, were placed by surgeon in the surgical incision, in the rectus abdominis muscle sheath, subperitoneally, over the peritoneum. A single dose of 10 ml of 1% lidocaine and 0.375% ropivacaine was administered from each On-Q SilverSoaker catheter. Through an IVPCA pump, they received a single dose of morphine (titrated dose according to age, weight, etc.) before the end of the operation and postoperatively on demand. After the end of the operation, each of the two On-Q SilverSoaker catheters was connected to the elastomeric On-Q Pain Pump constant flow with 400 ml solution of 0.375% ropivacaine and an infusion rate of 2ml/h, from each lumen (2+2ml dual=4 ml/h). Patients in the third group (Group C= IVPCA) received intravenous (iv) analgesia with 1gr paracetamol X3 and 8mg lornoxicam X2 per day and via a PCA pump they received on demand opioid and specifically a solution of 30mg morphine in 100ml Normal Saline (N/S) with a limit of 30mg/24 hours. Before the end of the operation they received a single dose of morphine (titrated dose depending on age, weight, etc.) and 1gr paracetamol and 8mg lornoxicam intravenously. All patients in the group received general anesthesia, with the use of fentanyl and an antiemetic, intraoperatively. Postoperative analgesia was maintained for 48 hours regardless of method. The effectiveness of each type of analgesia was assessed by the Numerical 11-point pain rating scale (NRS) (none: 0, mild: 1-3, moderate: 4-6, severe: 7-9, worst: 10). Other variable were recording including consumption of morphine, recovery of bowel function, vital signs, oxygen saturation, itching and length of stay. Patient satisfaction from the pain relief (using a two –point rating scale: Yes, No) and from the pain relief by the nursing staff (using a three –point rating scale: Little – Moderate- Very) was also recorded. Additionally, urination, resuscitation, and movement with assistance were recorded during the same period.

Measurements.

PP assessment was performed at rest and during coughing 3 times, (one in each shift) per 24hours, for 4 consecutive days (Day of surgery, 1st, 2nd and 3rd postoperative day).

Statistical Analysis

The Kolmogorov-Smirnov criterion was used to test the distributions of quantitative variables for normality. Mean, standard deviation (SD), median, and interquartile range were used to describe quantitative variables. Absolute (n) and relative (%) frequencies were used to describe categorical and ordinal variables. Pearson's chi-square test or Fisher's exact test were used for comparing categorical variables between types of analgesia. Analysis of variance (ANOVA) or the non-parametric Kruskal-Wallis test was used to compare quantitative variables among types of analgesia. Bonferroni correction was used in case of multiple testing in order to control for type I error. Repeated measures analysis of variance (ANOVA) was used to test for differences in pain measurements among groups and over time. Additionally, this method was used to assess whether the degree of change in pain over time differed among the analgesia groups. All reported p values are two-tailed. Statistical significance was set at $p<0.05$ and analyses were conducted using SPSS statistical software (version 26.0).

RESULTS

This study was conducted during the recent COVID-19 pandemic so the impact on sampling recruitment methods should not be ignored. The studied sample consisted of 89 patients, with mean age 62.7 years (SD=17.8 years), who underwent a surgery. Sample's demographic and clinical characteristics, by type of analgesia, are presented in table 1. The duration of surgery, recovery and length of stay were similar among the three groups.

PP at rest decreased significantly throughout the follow-up period time in all three analgesia groups ($p<0.001$ for Group EA, $p<0.001$ for Group On-Q, and $p=0.001$ for Group IVPCA). However, the degree of reduction differed significantly among the

three groups (p=0.013). Specifically, in the On-Q group, the reduction occurred on the day of surgery, while in the other analgesia methods, it occurred the following day. Nevertheless, pain levels in the On-Q group were consistently lower than those in the other two groups throughout the duration of the study (Figure 1). For the cough-induced pain, after Bonferroni correction, it was found that PP scores in Group EA were significantly higher compared to Group On-Q throughout the follow-up period. Additionally, PP scores in IVPCA Group were significantly higher in all timepoints compared to Group On-Q. Group EA and Group IVPCA had similar PP scores throughout the monitoring period. Cough-induced pain decreased over time in all three analgesia groups (p<0.001 for all three groups). The degree of reduction was similar across the three groups (p=0.539). However, PP scores in the On-Q group were consistently lower than those in the other two groups throughout the duration of the study (Figure 2).

The percentages of morphine consumption differed significantly among the three groups (Table 2). After Bonferroni correction, it was found that Group EA had significantly higher morphine consumption percentage both on the day of surgery (p<0.001) and during the postoperative days (p<0.001 for the 1st one, p=0.002 for the 2nd and 3rd one) compared to Group On-Q. Additionally, on the 2nd postoperative day, the morphine percentage was significantly higher in Group EA compared to Group IVPCA (p=0.008).

The antiemetic percentages differed significantly among the three groups on the day of surgery (p<0.001), on the 1st(p<0.001) and 2nd (p=0.001) postoperative day. After Bonferroni correction, it was found that Group EA had significantly higher antiemetic percentage both on the day of surgery and during the first two postoperative days compared to Group On-Q. Additionally, on the day of surgery and on the 2nd postoperative day, the antiemetic percentage was significantly higher in group EA compared to group IVPCA. The pruritus percentages did not differ significantly among the three groups of analgesia (p>0.05). Recovery of bowel function was similar across all three types of analgesia (p>0.05), both on the day of surgery and during the postoperative period. Regarding patient's mobilization, on the day of surgery, the majority of all groups required assistance to move, with similar percentages (93.2% in EA group, 90% in the On-Q group and 73.3% in the IVPCA group). On the first postoperative day, the percentage of movement with assistance differed between analgesia types, and specifically, after Bonferroni correction, the difference was found between group EA (59.1%) and Group On-Q (10%), p<0.001. In the subsequent postoperative days, the percentages of movement with assistance were similar across all groups (p>0.05).

The systolic artery pressure (SAP) values on the day of surgery and on the first postoperative day differed significantly among the three groups (table 3). Specifically, after Bonferroni correction, it was found that SAP values were significantly higher in IVPCA group compared to EA group (p=0.003 for day of surgery and p=0.003 for the 1st postoperative day) and On-Q group (p<0.001 for day of surgery and p=0.046 for the 1st postoperative day). However, the values of diastolic artery pressure (DAP), heart rate, and SpO2 did not differ significantly among the three groups (p>0.05).

Groups' PP scores are presented in table 4. Significant differences were observed in all timepoints among patients receiving different types of analgesia. Specifically, after Bonferroni correction, it was found that PP scores in Group EA were significantly higher compared to Group On-Q throughout the follow-up period. Additionally, PP scores in IVPCA were significantly higher in most measurements compared to On-Q Group. Patients with EA and those with IVPCA had similar PP scores throughout the monitoring period (p>0.05).

Significant differences were observed in satisfaction from analgesia percentages, among the three groups, with the highest percentages found in the On-Q group (table 5). Additionally, patients On-Q group was more satisfied with analgesia on the day of the surgery compared to patients with PCA (p=0.012). Patients' satisfaction from the nursing staff did not differ significantly among the three groups.

DISCUSSION

The present study is the first to identify the effectiveness between three types of analgesia in patients undergoing MAS in the Greek setting. According to the most important findings of

the present study, the patients in all three groups were of similar gender, age and body mass index (BMI). There was a numerical superiority of the group with EA, due to the fact that EA remains the gold standard for some types of MAS despite the risk of complications. [12] No significant differences were found in smoking habits, comorbidities as diabetes, history of analgesics and other medication consumption. Duration of the operation, the LOS and recovery room stay were similar in the three groups. Group EA had significantly higher consumption morphine both on the day of surgery and in the postoperative days compared to group On-Q.

MAS are characterized by moderate to severe postoperative pain at rest and with movement.[16,17]

In our study, patients in all groups experienced moderate to mild pain in the immediate postoperative course, suggesting that pain was adequately managed. Despite increased awareness and recommendations for postoperative analgesia, analgesic goals are not always achieved.[4].However, in the present study, pain scores differed between groups. Patients with EA and patients with IVPCA experienced moderate pain (NRS>3.7 and <4.5) on the day of surgery, while patients in On-Q group experienced mild pain (NRS>1.47 and <2.93). This finding suggests that analgesia with the On-Q pump system is superior to EA and IVPCA.

The findings of the present study showed significant superiority of continuous surgical site analgesia with On-Q pump compared to the other types of analgesia in the management of PP both at rest and during coughing on all days of follow-up. Patients with EA felt more intense pain compared to patients On-Q group throughout the follow-up. The PP scores in IV PCA group (combination of paracetamol - lornexacam and opioids on demand) were significantly higher in the majority of measurements compared to On-Q group. Although there are not many studies in the international literature that compare the effectiveness of On-Q with other analgesic methods, our study found that continuous surgical site analgesia with On-Q pump is superior to EA or IVPCA in reducing pain intensity and consumption of opioid or in faster mobilization in the postoperative course. After nephrectomy and in agreement with our results Capdevila et al, in a similar study, concluded that both continuous surgical site analgesia and EA are effective in reduce PP scores and opioid consumption. [18] The investigators primarily assessed pain in the first 24 hours and secondarily assessed morphine consumption and postoperative course. At 24 hours, the mean ± standard deviation of pain at rest was 2.4 ± 1.7, 2.2 ± 1.2, and 4.2 ± 1.2, respectively, in the EA, On-Q, and IV PCA groups, P <.001) and during coughing was lower in EA and On-Q. Total morphine consumption was higher in IV PCA, while postoperative course was better in the EA and On-Q groups.

A similar study in patients with gastrectomy by Zheng et al, [19] showed that PP scores were similar in all 3 groups during the first 48 hours, but the morphine consumption was less in the On-Q group and in the IV PCA group. The mean total morphine consumption differed significantly between the groups [On-Q group=12.84 ± 4.07 mg , EA group=11.52 ± 4.62 mg, IV PCA=42.32 ± 7.25 mg in the during the first 48 hours (P < 0.001)]. In addition, the IV PCA group had more opioid-related side effects while the LOS was shorter in the On-Q and EA groups. Also, lower SAP was recorded in the EA group. The results of the study by Zheng et al, differ partially from ours and may be due to the fact the IVPCA group received only morphine and not multimodal analgesia. None of the two studies found continuous surgical site analgesia with On-Q pump inferior to EA or IVPCA, while in both studies the EA was superior to IVPCA. The effectiveness of infiltration of the surgical wound with local anesthetics depends in part on the level of tissue where the infiltration takes place. Inappropriate placement of catheter may impair the efficacy wound infiltration after abdominal surgery.

In our study, patients in the On-Q group reported lower PP scores compared to patients with EA. In addition, EA group had greater morphine consumption on the day of surgery and in the postoperative days compared to On-Q group, which suggests that EA did not completely relieve the pain. Consequently the result that EA group had significantly higher rates of antiemetic administration both on the day of surgery and on the first two postoperative days compared to On-Q group is also interpreted. Recovery of bowel function and pruritus did not differ between the two types of analgesia. It is known that opioids cause nausea, decreased bowel function, and pruritus. Regarding patient

mobilization, on day of surgery both groups needed help to move, while on the 1st postoperative day, more than half of the patients in EA group needed help to move, in contrast to the On-Q group where only 10% needed help. Several studies agree with our findings. [20-22] In particular, Mungroop et al [20] compared EA with continuous wound infiltration in patients undergoing hepato-pancreato-biliary surgery by subcostal or midline laparotomy and they suggested that continuous wound infiltration by On-Q pump is non inferior to epidural analgesia in hepato-pancreato-biliary surgery within an enhanced recovery setting. Araújo et al, concluded that continuous wound infiltration by On-Q pump is the technic with most efficacy and safety being even better than EA in postoperative pain control after major abdominal surgery. They also found that this type of analgesia is associated with better results, lower incidence of side effects and no residual pain contributing to enhanced recovery.[21] Similar results reported by Bertoglio et al, in patients with colorectal cancer surgery.[22] and by Ilangovan et al [23] in patients with gynecological surgeries.

On the contrary Mouawad et al,[24] and Jouve et al [25]resulted that EA provided quicker functional recovery than On-Q pump and reduced length of hospital stay in patients undergoing open colorectal surgery.

In our study, the PP scores of patients with IVPCA (combination of paracetamol - lornexacam and opioids on demand) were significantly higher in the majority of measurements compared to patients with an On-Q pump. Analgesia in surgical site with an On-Q pump was more effective in treating at rest and during coughing than IV PCA. In the international literature, there are many studies that agree with our finding and report the superiority of the On-Q pump over IV PCA in the postoperative course of patients either by reducing PP scores, opioid consumption or contributing to enhanced recovery. [2, 26-29]

The international literature reports several studies that have investigated the effectiveness of analgesia methods for postoperative care and patient satisfaction. The studies highlight the importance of choosing the appropriate analgesia method based on the patient's needs and preferences, taking into account the benefits and possible complications. There are studies published about 10 years ago that show the importance of the analgesia method for patients after MAS. In our study, patients with EA and those with IVPCA had similar postoperative pain scores at rest and during coughing throughout the follow-up period, but on the 2nd postoperative day, morphine consumption was significantly higher in EA group compared to IVPCA group .In contrast to this finding, Salicath, et al [12] conducted a systematic review of 32 randomized controlled trials with total population of 1716. The results showed that patients who received EA experienced greater pain relief at rest compared with those who received IVPCA. EA may reduce episodes of respiratory depression, but was accompanied by an increased risk of analgesia failure. In agreement with our study Ahmed et al,[30] compared EA to PCA analgesia and the results showed, that EA did not cause high PP scores Viderman et al.[31] who compared intravenous analgesia (IVPCA) with EA in patients undergoing intra-abdominal surgery. showed no significant differences in pain relief at rest, but EA showed slightly better results in pain relief during cough. Sedation scores were similar between the two methods, but EA was associated with a shorter length of stay. In contrast, (IVPCA) caused fewer episodes of hypotension and showed slightly better results in postoperative complications.

Patients in the On-Q group reported greater satisfaction with pain management. Also, On-Q patients were more satisfied with analgesia on the day of surgery, compared to PCA patients. Our findings are also supported by Zheng X, et al, and who, although they did not find a significant difference between the groups regarding satisfaction with pain relief, patients with an On-Q pump were most satisfied, followed patients with EA, while IVPCA had the lowest score. Several studies that have investigated the effectiveness of analgesia methods for postoperative care and patient satisfaction are reported in the international literature. [20,30]

Limitations of the study

The present study had some strengths and specific limitations. The first limitation of our study was the small sample size and that it was obtained from a single hospital, which probably influenced the results obtained. The second important limitation was that there was no randomization in the allocation of patients to the groups and there was no blinding in the study, which in-

creases the selection and allocation bias. However, the study revealed important findings on postoperative analgesia in MAS that may be the stimulus for future better designed studies.

CONCLUSIONS

Continuous anesthetic infusion in surgical site by an On-Q pump as a component of multimodal analgesia was found to be superior to epidural and intravenous multimodal analgesia in patients undergoing MAS. Although EA is considered the gold standard in some abdominal surgeries, anesthetic infusion in surgical site by an On-Q pump is more effective and safer in the management of acute PP. It also reduces overall opioid consumption and consequently their adverse effects while contributing to enhanced recovery after MAS. In the immediate postoperative period, nurses play an essential role in monitoring the intense of the patient's pain and communicating the need for further intervention to other team members as needed.

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ANNEX

TABLE 1. Sample's demographic and clinical characteristics, by type of analgesia.

		Type of analgesia						
		Epidural (n=44 ; 49.4%)	On-Q (n=30 ; 33.7%)	PCA (n=15 ; 16;9%)		P Epidural vs On-Q	P Epidural vs PCA	P PCA vs On-Q
		Mean(SD)	Mean(SD)	Mean(SD)	P			
Age (years)		64 (17.1)	62.8 (18.2)	58.7 (19.8)	0.617‡	>0.999	0.981	>0.999
BMI (kgr/m^2)		27.6 (4.4)	27.5 (4.3)	30.2 (6.3)	0.158‡	>0.999	0.220	0.241
		Median (IQR)	Median (IQR)	Median (IQR)				
Length of stay		5 (5 — 5.5)	5 (5 — 5)	5 (5 — 5)	0.898‡	>0.999	>0.999	>0.999
Duration of surgery		202.5 (180 — 300)	165 (120 — 200)	180 (120 — 330)	0.077‡	0.077	>0.999	0.541
Duration in recovery		30 (30 — 30)	30 (30 — 45)	30 (30 — 40)	0.569‡	0.870	>0.999	>0.999
		n (%)	n (%)	n (%)				
Gender	Men	27 (61.4)	19 (63.3)	10 (66.7)	0.933+	0.864+	0.714+	>0.999++
	Women	17 (38.6)	11 (36.7)	5 (33.3)				
BMI levels	Normal	9 (20.5)	8 (26.7)	1 (6.7)	0.455++	0.451+	0.596++	0.216++
	Overweight	24 (54.5)	18 (60)	10 (66.7)				
	Obese	11 (25)	4 (13.3)	4 (26.7)				
Smoking		21 (47.7)	8 (26.7)	4 (26.7)	0.121+	0.068+	0.154+	>0.999++
Diabetes		10 (22.7)	2 (6.7)	1 (6.7)	0.138++	0.066+	0.259++	>0.999++
Prior use of analgesics	None	44 (100)	28 (93.3)	14 (93.3)	0.166++	0.161++	0.254++	>0.999++
	Paracetamol	0 (0)	1 (3.3)	1 (6.7)				
	NSAIDs	0 (0)	0 (0)	0 (0)				
	Opioids	0 (0)	1 (3.3)	0 (0)				
Other medication		30 (68.2)	16 (53.3)	12 (80)	0.175+	0.196+	0.516++	0.082+
ASA	1	15 (34.1)	5 (16.7)	3 (20)	0.322++	0.142++	0.363++	>0.999++
	2	12 (27.3)	15 (50)	8 (53.3)				
	3	16 (36.4)	9 (30)	4 (26.7)				
	4	1 (2.3)	1 (3.3)	0 (0)				
Drains		40 (90.9)	25 (83.3)	10 (66.7)	0.085++	0.471++	0.038++	0.263++
Urinary catheter		41 (93.2)	27 (90)	13 (86.7)	0.695++	0.681++	0.593++	>0.999++
Use of blood or derivatives		10 (22.7)	9 (30)	1 (6.7)	0.209+	0.482+	0.259++	0.129++

Note. P-values in *italics* are significant after Bonferroni correction
+Pearson's χ^2 test ++Fisher's exact test ‡ANOVA

TABLE 2. Post-operative characteristics, by type of analgesia.

	Type of analgesia						
	Epidural (A) (n=44 ; 49.4%)	On-Q (B) (n=30 ; 33.7%)	IVPCA (C) (n=15 ; 16;9%)				
	n (%)	n (%)	n (%)	P	P Avs B	P A vs C	P B vs C
Morphin							
Day of surgery	40 (90.9)	14 (46.7)	12 (80)	<0.001+	*<0.001+*	0.355++	0.033+
1st post-op day	39 (88.6)	15 (50)	12 (80)	0.001+	*<0.001+*	0.407++	0.053+
2nd post-op day	29 (65.9)	9 (30)	4 (26.7)	0.002+	*0.002+*	*0.008+*	>0.999++
3rd post-op day	11 (25)	0 (0)	2 (13.3)	0.005++	*0.002++*	0.482++	0.106++
Anti-vomit							
Day of surgery	44 (100)	19 (63.3)	12 (80)	<0.001++	*<0.001+*	*0.014++*	0.321++
1st post-op day	42 (95.5)	19 (63.3)	12 (80)	0.002+	*<0.001+*	0.099++	0.321++
2nd post-op day	30 (68.2)	9 (30)	4 (26.7)	0.001+	*0.001+*	*0.005+*	>0.999++
3rd post-op day	12 (27.3)	3 (10)	2 (13.3)	0.147+	0.070+	0.483++	>0.999++
Itching							
Day of surgery	1 (2.3)	1 (3.3)	0 (0)	>0.999++	>0.999++	>0.999++	>0.999++
1st post-op day	2 (4.5)	2 (6.7)	1 (6.7)	>0.999++	>0.999++	>0.999++	>0.999++
2nd post-op day	5 (11.4)	1 (3.3)	2 (13.3)	0.423++	0.391++	>0.999++	0.254++
3rd post-op day	1 (2.3)	0 (0)	0 (0)	>0.999++	>0.999++	>0.999++	-
Diuresis							
Day of surgery	44 (100)	30 (100)	15 (100)	-	-	-	-
1st post-op day	44 (100)	30 (100)	15 (100)	-	-	-	-
2nd post-op day	44 (100)	30 (100)	15 (100)	-	-	-	-
3rd post-op day	44 (100)	30 (100)	15 (100)	-	-	-	-
Bowel mobility							
Day of surgery	42 (95.5)	26 (86.7)	13 (86.7)	0.286++	0.215++	0.265++	>0.999++
1st post-op day	42 (95.5)	24 (80)	14 (93.3)	0.107++	0.055++	>0.999++	0.395++
2nd post-op day	43 (97.7)	28 (93.3)	14 (93.3)	0.494++	0.562++	0.447++	>0.999++
3rd post-op day	43 (97.7)	26 (86.7)	15 (100)	0.111++	0.151++	>0.999++	0.285++
Assistance to move							
Day of surgery	41 (93.2)	27 (90)	11 (73.3)	0.100++	0.681++	0.062++	0.199++
1st post-op day	26 (59.1)	3 (10)	6 (40)	<0.001+	*<0.001+*	0.200+	0.042++
2nd post-op day	6 (13.6)	2 (6.7)	2 (13.3)	0.660++	0.461++	>0.999++	0.591++
3rd post-op day	2 (4.5)	2 (6.7)	2 (13.3)	0.453++	>0.999++	0.265++	0.591++

Note. P-values in *italics* are significant after Bonferroni correction
+Pearson's χ^2 test ++Fisher's exact test

TABLE 3. Patients' blood pressure. heart rate and SpO2 measurements. by type of analgesia

	Type of a analgesia						
	Epidural (A) (n=44 ; 49.4%)	On-Q (B) (n=30 ; 33.7%)	IVPCA (C) (n=15 ; 16;9%)				
	n (%)	n (%)	n (%)	P	P Avs B	P A vs C	P B vs C
SBP							
Day of surgery	129.2 (14.2)	125.6 (8.5)	142.6 (16.6)	<0.001‡	0.754	*0.003*	*<0.001*
1st post-op day	122.6 (15)	125.5 (8)	135.2 (11)	0.005‡	0.997	*0.003*	*0.046*
2nd post-op day	120.1 (12.4)	121.3 (3.4)	123.7 (7.7)	0.451‡	>0.999	0.635	>0.999
3rd post-op day	122.4 (10.8)	123 (1.3)	125.7 (7.3)	0.414‡	>0.999	0.561	0.929
DBP							
Day of surgery	77.1 (11.9)	75.8 (6.8)	82.2 (10.3)	0.136‡	>0.999	0.290	0.153
1st post-op day	72.3 (10.2)	70.8 (5.3)	76.2 (7.4)	0.126‡	>0.999	0.372	0.128
2nd post-op day	69 (12.6)	68.8 (4.1)	72.9 (9.2)	0.372‡	>0.999	0.574	0.597
3rd post-op day	71.2 (5.2)	68.9 (2.3)	69.2 (5.8)	0.081‡	0.109	0.459	>0.999
HR							
Day of surgery	78.1 (9.2)	74.4 (5.4)	80.1 (14)	0.099‡	0.270	>0.999	0.158
1st post-op day	75.1 (8.7)	72.2 (4.5)	75.1 (6.7)	0.214‡	0.295	>0.999	0.623
2nd post-op day	74.2 (7.4)	74.2 (4.9)	76.5 (6.7)	0.459‡	>0.999	0.730	0.772
3rd post-op day	76.3 (4.7)	74.9 (4)	76.2 (1.7)	0.316‡	0.428	>0.999	0.961
SpO2							
Day of surgery	99.2 (1.1)	98.9 (0.6)	99.1 (0.6)	0.414‡	0.581	>0.999	>0.999
1st post-op day	99.2 (1.2)	98.9 (0.6)	99.3 (0.6)	0.234‡	0.380	>0.999	0.525
2nd post-op day	99.2 (0.8)	99 (0.4)	99 (0.7)	0.295‡	0.435	0.958	>0.999
3rd post-op day	99.1 (0.5)	98.9 (0.4)	99 (0.4)	0.474‡	0.674	>0.999	>0.999

Note. P-values in *italics* are significant after Bonferroni correction
‡ANOVA

TABLE 4. Patients' pain measurements, by type of analgesia

		Type of analgesia						
		Epidural (A) (n=44 ; 49.4%)	On-Q (B) (n=30 ; 33.7%)	IVPCA (C) (n=15 ; 16;9%)				
		n (%)	n (%)	n (%)	P	P Avs B	P A vs C	P B vs C
Pain at rest								
Day of surgery	08:00 am	4 (4 — 5)	3 (1 — 3)	4 (3 — 5)	0.001	*<0.001*	0.943	*0.012*
	16:00 pm	4 (3 — 5)	1 (1 — 2)	4 (3 — 5)	<0.001	*<0.001*	0.671	*<0.001*
	24:00 pm	4 (3 — 4)	1 (1 — 2)	4 (3 — 4)	<0.001	*<0.001*	0.650	*<0.001*
1st post-op day	08:00 am	3 (2 — 4)	1 (1 — 2)	4 (2 — 4)	0.004	*0.001*	0.883	0.062
	16:00 pm	4 (2 — 4)	1 (0 — 2)	2 (2 — 4)	<0.001	*<0.001*	0.277	*0.005*
	24:00 pm	3 (2 — 4)	1.5 (1 — 2)	2 (2 — 4)	0.006	*0.001*	0.501	0.082
2nd post-op day	08:00 am	3 (2 — 3)	1 (1 — 2)	3 (2 — 4)	<0.001	*<0.001*	0.891	*0.006*
	16:00 pm	3.5 (2 — 4)	2 (1 — 2)	3 (2 — 4)	0.003	*0.001*	0.964	0.039
	24:00 pm	3 (2 — 4)	1 (1 — 2)	2 (1 — 4)	0.007	*0.002*	0.495	0.069
3rd post-op day	08:00 am	2 (2 — 2)	1 (0 — 1)	2 (2 — 3)	<0.001	*<0.001*	0.104	*<0.001*
	16:00 pm	3 (2 — 3)	1 (1 — 2)	3 (2 — 3)	<0.001	*<0.001*	0.949	*0.001*
	24:00 pm	3 (2 — 3)	1 (1 — 2)	2 (2 — 4)	<0.001	*<0.001*	0.971	*<0.001*
Cough-induced pain								
Day of surgery	08:00 am	5 (4 — 5)	3 (3 — 4)	5 (4 — 6)	<0.001	*<0.001*	0.489	*<0.001*
	16:00 pm	5 (4 — 5)	3 (2 — 3)	4 (4 — 6)	<0.001	*<0.001*	0.778	*<0.001*
	24:00 pm	4 (4 — 5)	3 (2 — 3)	4 (4 — 5)	<0.001	*<0.001*	0.986	*<0.001*
1st post-op day	08:00 am	4 (4 — 5)	3 (3 — 3)	4 (4 — 5)	<0.001	*<0.001*	0.514	*<0.001*
	16:00 pm	4 (3.5 — 5)	3 (2 — 3)	4 (3 — 5)	0.001	*0.001*	0.642	*0.001*
	24:00 pm	4 (3 — 4)	2.5 (2 — 3)	3 (3 — 5)	0.002	*0.001*	0.978	*0.005*
2nd post-op day	08:00 am	4 (3 — 4)	2 (2 — 3)	4 (4 — 4)	<0.001	*<0.001*	0.390	*<0.001*
	16:00 pm	4 (3 — 4.5)	3 (2 — 3)	4 (4 — 4)	0.003	*0.003*	0.948	*0.004*
	24:00 pm	3 (2 — 4)	2 (1 — 3)	3 (3 — 4)	0.001	*0.001*	0.781	*0.001*
3rd post-op day	08:00 am	3 (2 — 4)	2 (1 — 2)	3 (2 — 3)	0.001	*0.001*	0.747	*0.004*
	16:00 pm	4 (3 — 4)	2 (1 — 2)	3 (2 — 4)	<0.001	*<0.001*	0.651	*0.002*
	24:00 pm	2 (2 — 3)	1 (1 — 2)	2 (2 — 3)	<0.001	*<0.001*	0.904	*0.002*

Note. P-values in *italics* are significant after Bonferroni correction
+Kruskal-Wallis test

TABLE 5. Patients' satisfaction. by type of analgesia

		Type of analgesia						
		Epidural (A) (n=44 ; 49.4%)	On-Q (B) (n=30 ; 33.7%)	IVPCA (C) (n=15 ; 16;9%)	P	P	P	P
		n (%)	n (%)	n (%)	n (%)	A vs B	A vs C	B vs C
Satisfaction from analgesia								
Day of surgery		33 (75.0)	29 (96.7)	10 (66.7)	0.020+	0.021++	0.522++	*0.012*++
1st post-op day		33 (75)	29 (96.7)	11 (73.3)	0.037+	0.021++	>0.999++	0.036++
2nd post-op day		33 (75)	29 (96.7)	11 (73.3)	0.037+	0.021++	>0.999++	0.036++
3rd post-op day		36 (81.8)	30 (100)	12 (80)	0.020++	0.018++	>0.999++	0.032++
Satisfaction from nursing staff								
Day of surgery	Low	0 (0)	1 (3.3)	0 (0)				
	Moderate	4 (9.1)	1 (3.3)	1 (6.7)				
	High	40 (90.9)	28 (93.3)	14 (93.3)	0.643++	0.351++	>0.999++	>0.999++
1st post-op day	Low	2 (4.5)	0 (0)	0 (0)				
	Moderate	1 (2.3)	1 (3.3)	0 (0)				
	High	41 (93.2)	29 (96.7)	15 (100)	0.888++	0.762++	>0.999++	>0.999++
2nd post-op day	Low	1 (2.3)	0 (0)	0 (0)				
	Moderate	1 (2.3)	0 (0)	0 (0)				
	High	42 (95.5)	30 (100)	15 (100)	>0.999++	>0.999++	>0.999++	-
3rd post-op day	Low	0 (0)	0 (0)	0 (0)	>0.999++	>0.999++	>0.999++	-

Note. P-values in *italics* are significant after Bonferroni correction
+Pearson's χ^2 test ++Fisher's exact test

FIGURE 1. Changes in pain at rest, by analgesia group

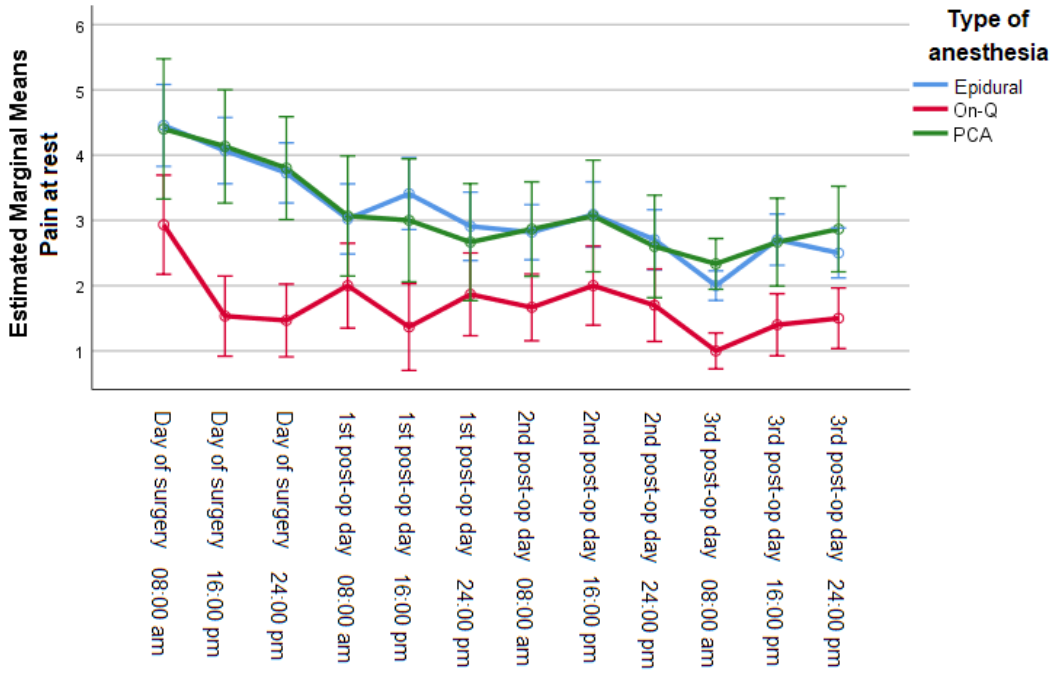
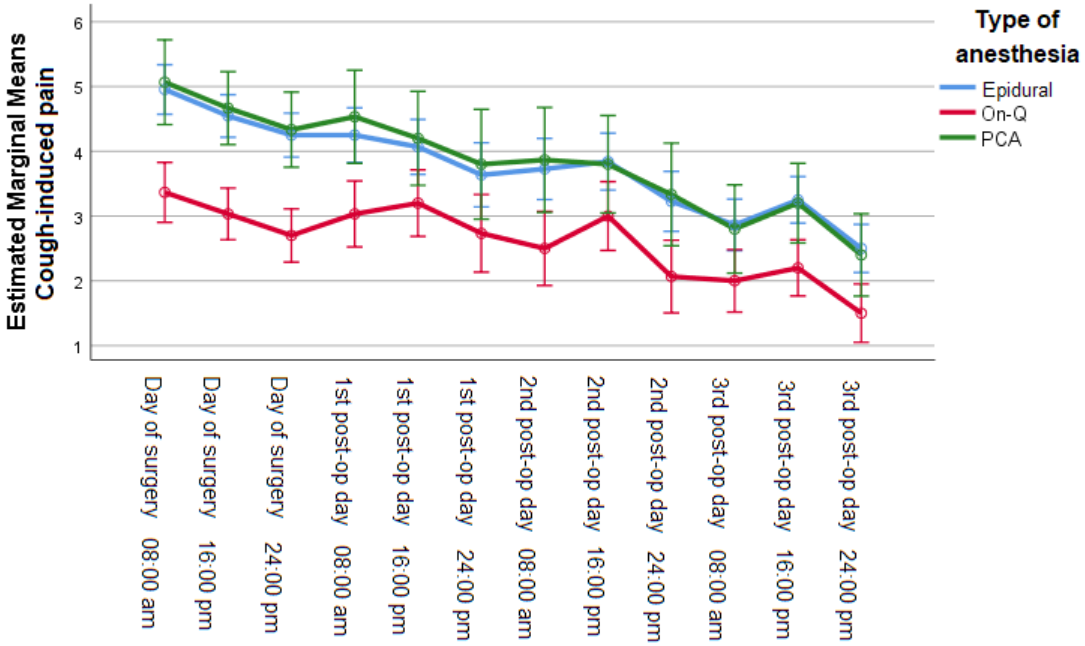
FIGURE 2. Changes in cough-induced pain, by analgesia group