Randomized Controlled Trial

The Antioxidant Effect of Selenium on Succinylcholine-related Myalgia After Adult Sinuscopies: Randomized Controlled Double-Blind Trial

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Background: Succinylcholine has a fast onset, short duration of action, and is considered the choice for rapid sequence intubation. However, it produces muscle stiffness and postoperative myalgia (POM) as adverse effects. We hypothesized that the antioxidant selenium might affect POM incidence and severity.

Objectives: The study aimed to investigate the antioxidant effect of selenium (against free radicals' release) in minimizing the frequency of succinylcholine-related POM, measured by the 4-point myalgia score. The severity of fasciculations and the postoperative analgesic profile were recorded. The correlation between fasciculations and POM was also observed.

Study Design: A prospective randomized controlled double-blind clinical study.

Setting: Assiut University Hospitals.

Methods: The current study included 80 adult patients scheduled for sinuscopies and randomly assigned into 2 equal groups. Two hours before the induction of general anesthesia, patients in the control group received oral placebo tablets, while patients in the selenium group received oral selenium 200 µg. The primary outcome of this trial was the POM score at 24 hours. Secondary outcomes included the intensity of fasciculations, Numeric Rating Scale (NRS), rescue analgesic consumption, and adverse effects of the studied drugs.

Results: Myalgia scores were significantly decreased after selenium administration throughout the follow-up period ($P = 0.023$). No significant difference was reported regarding the incidence or degree of fasciculations ($P = 0.511$). A mild correlation was noticed between fasciculations and POM with $r = 0.176$ and $P < 0.061$. The NRS values were significant between groups at 6 hours after the procedure. There were significant differences ($P < 0.05$) regarding postoperative supplement analgesia, time to the first rescue analgesia, and the mean total number of analgesic claims. Significant differences were recorded for potassium levels only 30 minutes and creatine kinase levels at 6 and 24 hours postoperatively.

Limitations: This study was applied on a single surgical category and other types of surgical procedures may have an effect on outcomes. Additional larger sample size studies and various doses of selenium may help to validate our results. Selenium is quite a significant element of the enzymatic antioxidant process through glutathione peroxidase. We did not measure the glutathione peroxidase level in blood.

Conclusions: Oral selenium effectively reduced the succinylcholine-induced postoperative myalgia. It prolonged the time to first required analgesia and decreased the analgesic consumption throughout the whole study period without affecting the hemodynamics or any serious adverse effects.

Key words: Adult sinuscopy, fasciculation, postoperative myalgia, succinylcholine, selenium

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Succinylcholine has a fast onset and short duration of action, hence it is considered the preferred drug for rapid sequence induction of anesthesia. Endotracheal intubation became easier due to the intensive neuromuscular block induced by succinylcholine (1). However, it produces muscle stiffness and postoperative muscle pain as side effects. The prevalence of succinylcholine-related myalgia extends from 41% to 92% (2). Succinylcholine-induced postoperative myalgia (POM) appears most prominently in the muscles of the shoulder, neck, back, and abdomen. It is mostly seen in surgical procedures that allow early ambulatory movement. The accurate underlying mechanism of muscle pain induced by succinylcholine is unknown, but it is believed that many mechanisms, including the increased intramuscular calcium concentration, the deterioration of the membrane phospholipid, the release of free fatty acids, and free radicals, are thought to be the causal factors (3). Various pretreatment methods were used in an attempt to diminish the intensity of POM caused by succinylcholine, including benzodiazepines, non-depolarizing muscle relaxants, local anesthetics, ketorolac, vitamin E derivatives, phenytoin, chlorpromazine, rocuronium, and remifentanil (4). Administration of succinylcholine frequently causes POM, a common troublesome symptom, which is associated with muscle damage and elevated muscle-related enzymes (5).

Free radical compounds are produced as the consequence of adenosine triphosphate (ATP) generation by mitochondria. These components are mostly Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS) resulting from the cellular activity. These by-products have a double action, as both are found in harmful and beneficial combinations. It is clear that the rigorous balance between these opposing effects is a crucial aspect. At moderate or low levels, ROS and RNS extend beneficial results on immune function and cellular response. At higher concentrations, they produce oxidative stress, which is harmful and can destroy all cell structures (6). Muscle damage may result in free radicals and further cellular damage from oxidation of fats and proteins (7).

Selenium is an essential trace element that may serve as a co-factor for antioxidant enzymes. It is also a structural part of a large group of selenoproteins that are important for proper body functions including regulating the inflammatory cytokines, inducing homeostasis, and protecting against free radicals that cause cell damage. The functional metabolized form (selenocysteine) is a component of the active site of glutathione peroxidase, which is a major selenoprotein found in the human body to control free radicals at the site of inflammation. The fundamental proofs suggest that the production of free radicals leads to increased oxygen absorption over time. The indirect effect, though important as selenium supplementation, is to save cells from oxidative stress and free radical production. Natural selenium includes 200 mg of this ingredient, which has high absorption ability and long-term retention (8).

We attempted to investigate the antioxidant effect of selenium against the release of free radicals after succinylcholine-induced muscle injury. We hypothesized that selenium might help in decreasing succinylcholine-induced POM incidence, severity, and adverse effects.

Methods

Study Design and Eligibility

This prospective randomized, placebo-controlled, double-blind study was conducted at Assiut University Hospitals after approval from the Institutional Ethics Committee (ref. IRB17100429 on March 2018). Then the study was registered in ClinicalTrials.gov, before enrollment of patients (ref. NCT03476044 on March 2018). The study adhered to the regulations of the Helsinki Declaration and written informed consent was obtained from patients scheduled to have adult sinuscopy procedures under general anesthesia.

Randomization, Blinding, and Drug Coding

Using a computer-generated table of random numbers, patients were randomly assigned into 2 equal groups (of 40 patients each) to receive the coded drugs. All tablets were detached from their strips and were stocked in opaque envelopes. Access to the envelopes was only obtainable by the anesthesiologist who filled out the envelopes. The anesthetic technique and outcome data were controlled by an anesthesiologist who was not included in the administration of study drugs or envelop coding. Neither the anesthesiologist providing anesthesia, nor the patients themselves were aware of group allocation to ensure blindness of the study.

Sample size calculation was based on the previous literature (3-5), where the incidence of postoperative muscle pain in outpatients was over 70%, and an intervention that could reduce this incidence by 50% would

be of interest. Using G*Power 3 software (11) with a study power of 90% and type I error of 5%, 37 patients in each group were required (α = 0.05 and β = 90%). The number of patients was increased to a total of 80 patients in order to compensate for the possibility of missing samples (dropouts) throughout the study.

Inclusion Criteria

Adult patients 20-40 years old, both genders, ASA physical status I or II, and scheduled for elective sinuscopic procedures.

Exclusion Criteria

Abnormal hepatic or renal function tests, history of chronic pain on chronic analgesia, history of seizure disorders, hyperkalemia, systemic diseases, such as hypertension, diabetes, increased intraocular or intracranial pressure, pregnancy, and history of drug-induced muscle pain.

Control Group (Group C)

Forty patients received oral starch tablets (similar-looking) with sips of water 2 hours before induction of general anesthesia.

Selenium Group (Group S)

Forty patients received oral selenium 200 µg with sips of water 2 hours before induction of general anesthesia.

Study Protocol

Preoperative assessment and evaluation of patients participating in the study were done in the preoperative anesthesia clinic, where full study protocol was explained to the patients. All patients could stop the study at any stage, with no effect on their medical service. With no premedication or perioperative intramuscular injections, the study drugs were given to all patients 2 hours before the induction of anesthesia by a single anesthesiologist, blinded to the envelopes coding.

Intraoperative monitoring (electrocardiogram [ECG], heart rate [HR], non-invasive blood pressure [NIBP], oxygen saturation [SpO_2], end-tidal carbon dioxide[$EtCO_2$]) was connected and the baseline values were documented. A 20G intravenous line was inserted in the hand and NaCl 0.9% volume was calculated and infused. Pre-oxygenation with 100% O_2, via facemask, then anesthesia was initiated with fentanyl 1 µg/kg, propofol 2 mg/kg, and succinylcholine 1.5 mg/kg.

Fasciculations based on a 4-point scale (9) were assessed for incidence and intensity by an anesthesiologist blinded to the group allocation. The scale key is as follows, 0: Absent, 1: Mild (fine fasciculations at the eyes, neck, face, or fingers without limb movement), 2: Moderate (fasciculations occurring bilaterally or obvious limb movement), and 3: Severe (widespread, sustained fasciculations). At the end of fasciculations, vital signs (HR, NIBP, SpO_2, and $EtCO_2$) were recorded then every 5 minutes after endotracheal intubation and throughout the procedure. Anesthesia was maintained with oxygen (100%) and sevoflurane (2-4%). All surgeries were carried out by the same surgical group.

Once the surgical procedure finished, all patients received paracetamol 1 g intravenously (Perfalgan, 100 ml/paracetamol 1000 mg, UPSA laboratories, France). Then tracheal extubation was done according to the criteria of extubation and patients were transported to the recovery zone, then were taken home after meeting discharge criteria.

Pain Assessment

POM

Myalgia is defined as non-invasive pain with no surgical interference and is based on a 4-point scale (3). It has been identified the incidence and severity of muscular pain in all patients at the ending of the first day after surgery by an anesthesiologist who was not aware of the allocation of selenium or placebo for any of the patients. Grading was 0: no myalgia, 1: muscle stiffness limited to one area of the body, 2: myalgia or stiffness noticeable spontaneously by the patient in need of analgesics, and 3: generalized severe myalgia or muscle stiffness.

NRS Pain Score

NRS was measured during rest (10). The NRS is a digital segmented version of the visual analog scale (VAS), where respondents select a whole number (0–10) that better mirrors the intensity of their pain. Its popular design is a horizontal strip or line. An 11-point digital scale (NRS 11) with 0 demonstrating one pain ultimate (no pain) and 10 demonstrating the other pain ultimate (worst imaginable pain). NRS was used instantly at the recovery sector at 1, 2, 4, 6, 12, and 24 hours after surgery. Pain related to POM or the surgical intervention was treated with 1 g paracetamol intravenously when the NRS was more than or equal to 4. The total number of analgesic doses within 24 hours was recorded.

Blood Sampling

A venous blood sample of 4 ml volume was collected from each patient before anesthesia (time 0), then after 5 and 30 minutes, and 24 hours after giving succinylcholine, to measure the potassium (K+) concentrations in the blood. Serum creatine kinase (CK) concentration was measured at 0 and 30 minutes, and 6 and 24 hours after succinylcholine administration. Any complications, such as postoperative nausea, vomiting, headache, somnolence, or confusion were recorded and treated accordingly.

Outcome Measures

The primary outcome of the study was the postoperative myalgia score at the end of 24 hours after the procedure (to evaluate the efficacy of selenium as an antioxidant against the free radicals' release from succinylcholine-induced muscle injury). Secondary outcomes included the intensity of fasciculations, NRS pain score, time to first rescue analgesia, total number of analgesic requirements within 24 hours, serum K+ and CK levels, and adverse effects of the studied drug in subjects undergoing sinuscopic procedures, under general anesthesia.

Statistical Analysis

Data were verified, coded by the researcher, and analyzed using IBM-SPSS version 21.0 (IBM-SPSS Inc., Chicago, Illinois, USA) (12).

Descriptive Statistics

Means, standard deviations, and percentages were calculated.

Tests of Significances

Chi-squared test was used to compare the difference in frequencies distribution among different groups. Independent t-test analysis was performed to compare the means for dichotomous data. Repeated measure ANOVA was used to compare the mean difference over time. Spearman's Ranked Correlation was used to check the correlation between fasciculations and postoperative muscle pain. The *P*-value less than 0.05 was classified as statistically significant.

Results

The study was carried out on 80 adult patients scheduled for elective sinuscopic procedures and all of them underwent the final statistical analysis. Figure 1 shows the CONSORT flow diagram of these study patients.

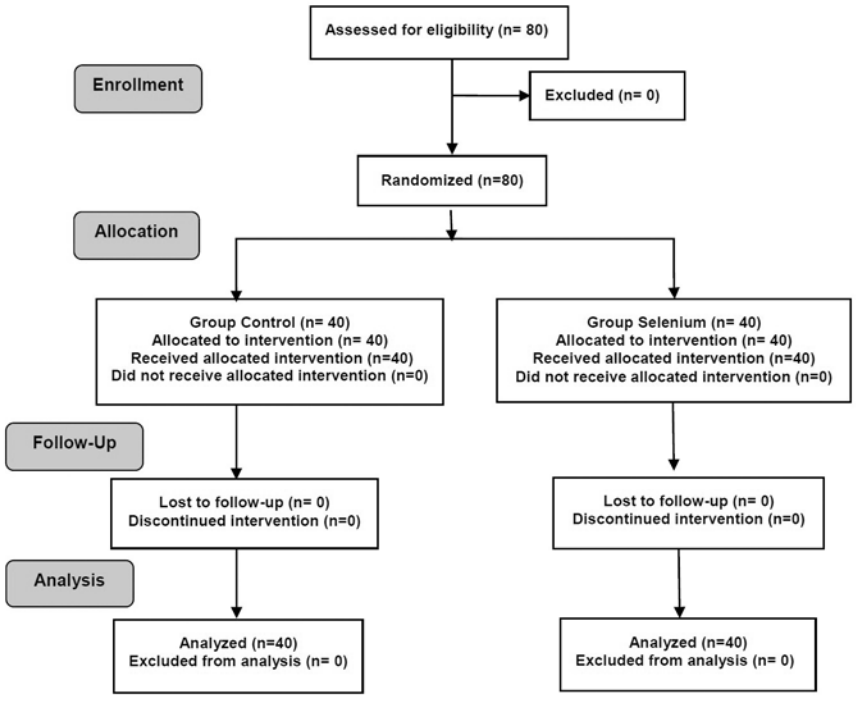

Fig. 1. *CONSORT flow diagram of the study patients.*

Patients' demographics were comparable between groups ($P > 0.05$) regarding age, gender, ASA status, weight, and height (Table 1). The mean age of control group patients was 29.30 ± 8.9 years, 18 men and 22 women. While the mean age of selenium group patients was 31.20 ± 8.4 years, 22 men and 18 women. In the control group, 19 patients were ASA-I and 21 patients were ASA-II, while in the selenium group, 24 patients were ASA-I and 16 patients were ASA-II. As regarding body mass index (BMI), there was a statistically significant difference between both groups ($P < 0.001$). Additionally, 57.5% of the control group patients and 17.5% of the selenium

group patients were of average weight (BMI < 24). The majority of the selenium group patients (82.5%) were overweight (BMI > 24), while 42.5% of the control group patients were overweight (Table 1).

The mean anesthesia and surgery times in the control group were 56.63 ± 19.1 minutes and 46.60 ± 17.4 minutes, while in the selenium group 50.25 ± 14.2 and 40.50 ± 12.3 minutes, respectively with no statistically significant difference between the 2 groups ($P > 0.05$) (Table 1).

Primary Outcome

POM showed a statistically significantly decrease after the administration of selenium, throughout the follow-up period with $P = 0.023$. Table 2 shows the distribution of both study groups in regards to POM incidence and grading. In the control group, 31 patients (77.5 %) showed no POM and 9 patients (22.5%) showed POM (3 patients grade 1, 4 patients grade 2, and 2 patients grade 3). In the selenium group 38 patients (95%) showed no POM and only 2 patients (5 %) showed POM of grade 1.

No statistically considerable difference was found between the groups ($P = 0.511$) in the incidence, or severity of fasciculations, measured by fasciculations score (Table 2). In the control group, 15% of patients had no fasciculations and 85% of patients had fasciculations (57.5% mild, 17.5% moderate, and 10% severe). While in the selenium group, 20% of patients had no fasciculations and 80% of patients had fasciculations (45% mild, 15% moderate, and 8% severe). There was a small positive correlation between fasciculations score (F-score) and postoperative myalgia score (M-score) during the observation period of the study with $r = 0.176$ and $P < 0.061$. As the fasciculations increased, the incidence and severity of POM also showed a mild increase (Fig. 2).

NRS for measuring pain showed no statistically significant differences between both groups, during the baseline time after recovery up to 4 hours postoperatively. There were significant variations between the groups' NRS values during the postoperative 6-, 12-, and 24-hour reports. In the control group, there was no statistically significant difference between follow-up NRS values and baseline readings ($P = 0.278$). While in the selenium group, there was a statistically significant difference when comparing the baseline readings ($P = 0.012$) measured with the ANOVA test measures (Table 3).

In the control group, 60% of patients did not need postoperative rescue analgesia and 40% of patients asked for analgesia. While in the selenium group, 75% of patients did not need postoperative rescue analgesia and 25% of patients asked for rescue analgesia. There was a statistically significant difference between both

Table 1. *Demographic and operative comparative analysis between study groups*

Variable	Control Group (n = 40)	Selenium Group (n = 40)	*P*-value
Age (years)	29.30 ± 8.9	31.20 ± 8.4	0.327*
Gender			0.371**
Women	22 (55%)	18 (45%)	
Men	18 (45%)	22 (55%)	
ASA Classification			0.262**
I	19 (47.5%)	24 (60%)	
II	21 (52.5%)	16 (40%)	
Weight (kg)	66.90 ± 6.0	69.38 ± 5.7	0.063*
Height (cm)	165.98 ± 7.0	163.80 ± 4.7	0.181*
BMI	24.30 ± 1.8	25.81 ± 1.1	< 0.001*
Normal Weight	23 (57.5%)	7 (17.5%)	< 0.001**
Overweight	17 (42.5%)	33 (82.5%)	< 0.001**
Duration of anesthesia (minutes)	56.63 ± 19.1	50.25 ± 14.2	0.097*
Duration of surgery (minutes)	46.60 ± 17.4	40.50 ± 12.3	0.094*

Data were presented as mean ± SD, number of patients, or percentages. *Independent t-test was used to compare the mean differences between groups. **Chi-square test was used to compare the percentages between groups. *P*-value < 0.05 was considered significant

Table 2. *Severity of fasciculations and POM grading between study groups*

Variable	Control Group (n = 40)	Selenium Group (n = 40)	*P*-value
Fasciculations			0.511*
No	6 (15%)	8 (20%)	
Mild	23 (57.5%)	18 (45%)	
Moderate	7 (17.5%)	6 (15%)	
Severe	4 (10%)	8 (20%)	
Postoperative Myalgia (POM)			0.023*
No	31 (77.5%)	38 (95%)	
1	3 (7.5%)	2 (5%)	
2	4 (10%)	0 (0%)	
3	2 (5%)	0 (0%)	

Data were presented as numbers of patients or percentages. *Chi-square test was used to compare the percentages between both study groups. *P*-value < 0.05 was considered significant.

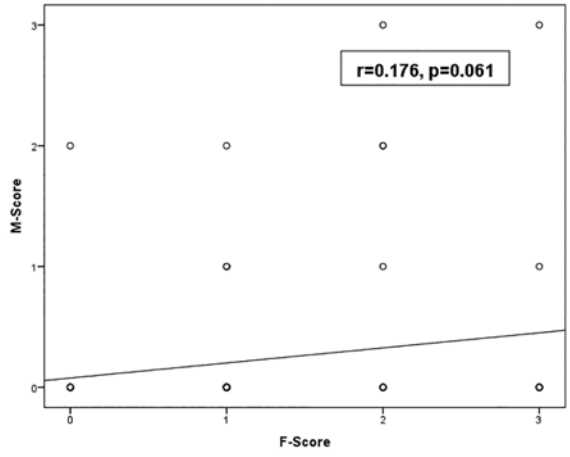

Fig. 2. *Correlation between fasciculations and postoperative myalgia scores.*

Table 3. *Numeric Rating Score (NRS) values between study groups*

Numeric Rating Scale (NRS)	Control Group (n = 40)	Selenium Group (n = 40)	P-value*
NRS (0=at recovery)	1.40 ± 0.3	1.00 ± 0.2	0.290
NRS (1 hour)	1.23 ± 0.2	1.17 ± 0.2	0.282
NRS (2 hours)	1.20 ± 0.2	1.24 ± 0.2	0.588
NRS (3 hours)	0.95 ± 0.2	0.82 ± 0.1	0.482
NRS (4 hours)	0.93 ± 0.1	0.73 ± 0.1	0.403
NRS (6 hours)	1.05 ± 0.2	0.63 ± 0.1	0.047
NRS (12 hours)	1.13 ± 0.2	0.74 ± 0.1	0.020
NRS (24 hours)	1.00 ± 0.2	0.78 ± 0.1	0.018
P-value**	0.278	0.012	

Data were presented as mean ± SD. *Independent t-test was used to compare the mean differences. **Repeated Measure ANOVA was used to compare the mean differences over time. *P*-value < 0.05 was considered significant.

groups regarding the postoperative supplement analgesia ($P = 0.047$). Time to the first postoperative rescue analgesia was delayed in the selenium group, with a statistically significant difference from that of the control group ($P = 0.047$). In the control group it was 1.41 ± 0.8 hours, while in the selenium group it was 2.90 ± 1.3 hours. The mean total number of postoperative analgesic requirements in the control group was 1.68 ± 0.1, while in the selenium group it was 1.20 ± 0.08, with a statistically significant difference between the groups ($P = 0.034$) (Table 4).

The distribution of postoperative complications in the study groups showed no statistically significant difference ($P = 0.762$). In the control group, no complications were reported in 33 patients (82.5%), while 7 patients (17.5%) showed postoperative complications (4 patients suffered from headache and 3 patients had nausea and vomiting). In the selenium group, there were 34 patients (85%) with no complications while 6 patients (15%) showed postoperative complications (4 patients had headache and 2 patients had nausea and vomiting) (Table 4).

No significant differences in HR, NIBP, SpO_2, or $EtCO_2$ readings between the groups during the whole time of the study, measured by repeated measure ANOVA test.

K+ levels showed a statistically significant difference between both groups only 30 minutes after the administration of succinylcholine ($P = 0.008$), measured by t-test. The control group showed higher K+ levels when compared to baseline values, than that of the selenium group with *P*-values 0.002 and 0.028 respectively, measured by repeated measure ANOVA test. There were statistically considerable differences between both groups regarding CK levels at 6 and 24 hours postoperatively, with *P*-values 0.037 and 0.009 respectively, measured by t-test. A higher increase CK levels was found in the control group in contrast to the baseline value ($P = 0.017$), but not in the selenium group ($P = 0.313$), measured by repeated measure ANOVA test (Table 5).

Discussion

POM after succinylcholine administration is a common and troublesome clinical problem found most frequently on the first postoperative day. The exact pathophysiology for succinylcholine-induced myalgia is not clear and a large variety of pretreatments were tested to avoid or decrease POM (4,13). The adverse effects related to succinylcholine, such as life-threatening hyperkalemia, are more common in the presence of certain comorbidities and thus preclude its use in such situations. In general, succinylcholine use is mostly limited to a suspected difficult airway or when a rapid safe airway is recommended (14).

With regard to the mechanism, which stated that the release of free radicals following muscle damage leads to POM, it proposes the use selenium as an antioxidant to prevent myalgia and, as far as we know, it is the first study to test this hypothesis, at very least within our region. The results of this trial presented

evidence that the incidence or severity of fasciculations had no statistically significant difference between the 2 groups, while POM had a significant difference between them. A small positive correlation between fasciculations and POM was observed.

Srivastava and colleagues used oral pregabalin to prevent succinylcholine-induced fasciculation and muscle pain. Pregabalin significantly affects muscle fasciculation by reducing the severity, but not its incidence. The myalgia intensity was lower in the pregabalin-treated group, in contrast to the control group. There is no correlation between the occurrence or degree of fasciculation and muscle pain (4). Other researchers have used higher doses of gabapentin to prevent fasciculation and myalgia induced by succinylcholine. They showed no significant change in the incidence of fasciculations between their groups, but showed a marked decrease in muscle pain. They found no association between the occurrence of fasciculation and myalgia (15). It is consistent with the results of another research study where the effects of dexmedetomidine on myalgia related to succinylcholine were observed early after surgery. The incidence and severity of fasciculations were better in the dexmedetomidine group, while the incidence and severity of POM were markedly higher in the control group (16).

Another investigator demonstrated the effect of magnesium sulfate on fasciculations and POM during the induction of general anesthesia, using propofol and succinylcholine. The occurrence of muscle fasciculations was 50% in the magnesium group versus 100% in the control saline group, with a statistically significant difference between both groups. No patient (0%) from the magnesium sulfate group reported POM, while 9 patients (30%) in the normal saline group reported POM after 24 hours, with a significant difference between the 2 groups (17).

Yun et al (9) examined whether remifentanil (1.5 μg/kg) could be used to decrease the succinylcholine-induced fasciculation or myalgia. Electromyography (EMG) was used to determine the range of muscle fasciculation following intravenous succinylcholine. The severity of visible muscle fasciculation in the remifentanil group was lower than in the saline group, while the incidence and duration of apparent muscle fasciculation were identical in both groups. The inhibitory mechanism of remifentanil on succinylcholine-induced muscular dystrophy stays unclear. It also showed the occurrence and severity of POM with no significant difference, where only a few cases showed mild muscle pain.

Table 4. *Postoperative analgesia and complications between study groups*

Variable	Control Group (n = 40)	Selenium Group (n = 40)	*P*-value
Need for postoperative analgesia			
No	24 (60%)	30 (75%)	0.047*
Yes	16 (40%)	10 (25%)	
Time to 1st rescue analgesia (hours)	1.41 ± 0.8	2.90 ± 1.3	0.047**
Total number of rescue analgesic doses	1.68 ± 0.1	1.20 ± 0.08	0.034**
Post-operative Complications			
No	33 (82.5%)	34 (85%)	0.762*
Headache	4 (10%)	4 (10%)	
Nauseas & Vomiting	3 (7.5%)	2 (5%)	

Data were presented as mean ± SD, number of patients, or percentages. *Chi-square test was used to compare the percentages between groups. **Independent t-test was used to compare the mean differences. *P*-value < 0.05 was considered significant.

Table 5. *Mean serum K+ and CK Levels between study groups*

Variable	Control Group (n = 40)	Selenium Group (n = 40)	*P*-value*
Serum K+			
K+ -0	4.50 ± 0.4	4.32 ± 0.4	0.066
K+ -5 minutes	4.83 ± 0.5	4.66 ± 0.4	0.076
K+ -30 minutes	4.89 ± 0.6	4.55 ± 0.5	0.008
K+ -24 hours	4.37 ± 0.6	4.42 ± 0.5	0.707
P-value**	= 0.002	= 0.028	
Serum CK			
CK -0	103.25 ± 12.4	110.85 ± 11.8	0.664
CK -30 minutes	130.40 ± 16.1	118.13 ± 12.7	0.551
CK -6 hours	181.30 ± 31.9	129.63 ± 16.1	0.037
CK -24 hours	243.00 ± 62.3	138.48 ± 20.9	0.009
P-value**	0.017	0.313	

Data were presented as mean ± SD. K+ = Potassium, CK = Creatine Kinase. *Independent t-test was used to compare the mean differences. **Repeated Measure ANOVA was used to compare the mean differences over time. *P*-value < 0.05 was considered significant.

Abraham et al (18) compared the effectiveness of rocuronium versus vecuronium in intubation and POM induced by succinylcholine. The statistical analysis showed significantly lower fasciculations in the rocuronium group. Both groups showed no significant difference with regard to POM at the first and third days after surgery.

The effect of high-dose propofol on succinylcholine-induced fasciculation and POM during induction of general anesthesia was studied. Less fasciculation was documented after the higher propofol dose (3.5 mg/kg) which was not severe. Although there are no statistically significant links between fasciculations and POM among these patients, both the incidence and severity of myalgia were significantly less in this group (3).

Shabanian et al (19) examined the effect of atracurium and methocarbamol on muscular fasciculations induced by succinylcholine. Methocarbamol is a muscle relaxant that is structurally related to guaifenesin and other muscle relaxants, such as mephenesin and chlorphenesin. They stated that the fasciculation incidence was significantly higher in patients taking methocarbamol, compared with patients taking atracurium. Similar to our results, other researchers looked at low-dose ketamine on succinylcholine-induced myalgia in outpatient surgical procedures. In the ketamine group, only 18.1% (13 out of 71 patients) suffered from muscle pain, while 50% (36 out of 72 patients) suffered from muscle pain in the normal saline group with a marked difference between the 2 studied groups (20).

The results of our study showed that postoperative pain assessment had statistically significant differences between the groups with regard to NRS readings 6 hours after the procedure. Also, there were statistically significant differences found in the postoperative supplement analgesia, time to first rescue analgesia, and the total number of analgesic requirements. Postoperative hemodynamic changes and complications did not show any statistically significant variation between the 2 studied groups.

This was the agreement of several studies that reported the reduced fentanyl consumption in the gabapentin group after surgery (15). Others documented that fentanyl consumption in the first 24-hours postoperative was remarkably lower in the pregabalin group, compared to the control group with better analgesia (4). Unlugenc et al (21) reported that a single dose of intravenous dexmedetomidine (1 μg/kg) reduced morphine consumption after surgeries at similar pain scores, when compared to the control group.

A pattern similar to our results was obtained in other studies where magnesium sulfate and propofol were tested for the effects of succinylcholine on fasciculation and myalgia. All patients showed continuous hemodynamic stability. There was no significant difference between groups for blood pressure and heart rate at any time with no serious complications (16). Celebi et al (22) noted the effects of dexmedetomidine on muscle pain due to succinylcholine in the early postoperative stage. Dexmedetomidine did not significantly reduce the HR or mean blood pressure. Changes in mean arterial blood pressure or HR were not markedly distinct between the study groups. Other investigators reported that their study showed no significant differences in pulse rate, systolic blood pressure, or diastolic blood pressure (19). Although the majority of patients in the selenium group were considered obese when compared to that of control group, we reported better outcomes after the selenium administration, which may require further investigations to verify the relationship between obesity and POM.

We reported statistically significant differences between the 2 study groups with respect to K+ level at 30 minutes and CK level at 6 hours after succinylcholine administration. Depolarization from succinylcholine results in a plasma potassium concentration change of approximately 0.5 - 1.0 mEq in the first 3-5 minutes after administration, depending on the dose. Mostly, hyperkalemia from succinylcholine lasts less than 10-15 minutes. Principle studies indicate that succinylcholine-induced hyperkalemia is proportionate to the number of acetylcholine receptors (22).

Skeletal muscle damage is a major cause of elevated CK levels during surgeries (4). Since muscle damage during various surgeries also raises this biochemical marker, patients undergoing sinuscopic procedures with minimal muscle injury were included in our study. Abraham, and his colleagues (18), did not find any statistically significant changes in the levels of K+ and CK when using rocuronium prior to the injection of succinylcholine. Another research detected the CK levels after using succinylcholine and reported that the average postoperative increase in the study groups was statistically significant (23). Other investigators notified a significant increase in K+ and CK levels following succinylcholine administration (9).

Succinylcholine is a good choice for urgent situations and short procedures that require endotracheal intubation. But unfortunately, it is associated with muscle fasciculation and myalgia after surgery, which requires vigilance cautions and interventions (24).

Limitations

The study was conducted on a single surgical category and other types of procedures may affect the outcomes. Additional larger sample size studies and various doses of selenium may help to validate our

results or ensure safety. Selenium is quite a significant element of the enzymatic antioxidant process through glutathione peroxidase (25). We did not measure the glutathione peroxidase level in blood.

Conclusions

Preoperative oral selenium therapy effectively reduced the succinylcholine-induced postoperative myalgia. It also prolonged the time to first required analgesia and decreased the total number of postoperative analgesic claims throughout the whole study period without affecting the hemodynamic status or inducing any serious adverse effects.

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