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Original Article

Effects of Using Intravenous Lidocaine on Reducing the Complications of Tracheal Tube Removal After Cardiac Surgery: A Randomized Clinical Trial

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ABSTRACT

Background: Coughing during anesthesia or extubation is a probable event that can cause hemodynamic changes due to an increase in chest pressure or the stimulation of the adrenergic system. We aimed to compare the effects of IV lidocaine with those of IV normal saline (as a placebo) on diminishing the incidence of coughs and sore throats, laryngospasms, and hemodynamic changes during tracheal extubation in the ICU after cardiac surgery.

Methods: The present randomized clinical trial assigned 50 candidates for simple cardiac valve or coronary bypass surgery to 2 groups (each group =25) to receive IV lidocaine or a placebo before tracheal tube removal after cardiac surgery in the ICU. Hemodynamic changes, the level of consciousness-restlessness (RASS), and the incidence of coughs were evaluated in both study groups. Four patients in the lidocaine group and 5 in the control group were lost to follow-up. Finally, 21 patients in the lidocaine group and 20 patients in the control group were analyzed.

Results: The rates of hemodynamic changes in the 2 groups were not statistically different. The changes in the level of consciousness based on the RASS were not significant in the 2 groups. The incidence of coughs based on the mentioned 3 criteria showed a statistically significant difference between the lidocaine and placebo groups.

Conclusions: IV lidocaine after cardiac surgery can be part of the weaning and extubation process without hemodynamic complications to reduce the incidence of coughs. ***(Iranian Heart Journal 2023; 24(3): 45-53)***

KEYWORDS: Anesthesia, Lidocaine, Cardiac surgery, Cough, Extubation

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The occurrence of coughs during anesthesia or after the removal of the endotracheal tube is an unwanted event that can cause hemodynamic changes in patients, such as an elevation in blood pressure, arrhythmias due to an increase in chest pressure, and the stimulation of the adrenergic system. [1] During heart surgery, it is crucial that any cause of hemodynamic instability be controlled to avoid an additional burden on the heart with a view to allowing the recently operated heart to adapt to the new conditions.

The present study aimed to compare the effects of injecting intravenous (IV) lidocaine with those of IV normal saline on reducing the incidence of coughs and sore throats, laryngospasms, and hemodynamic changes during tracheal extubation in the intensive care unit (ICU) after cardiac surgery.

The complications of tracheal tube removal during extubation include coughing, increased intrathoracic pressure due to the straining caused by the irritation of the tracheal tube wall, increased blood pressure, tachycardia, and arrhythmias. In addition, after the removal of the tracheal tube, the irritation of the tracheal wall can cause laryngospasms, which could be very dangerous. If it is not resolved through the usual and basic measures by the anesthesiologist, it may require reintubation, and sometimes cardiovascular complications occur. Therefore, applying the necessary measures during extubation can prevent these problems. [2]

What an anesthesiologist should take heed of includes a correct assessment of respiratory and cardiac status before extubation and the creation of a situation whereby complete wakefulness, breathing support, and relative relaxation with narcotic drugs can be ensured.

Lidocaine is a local anesthetic drug of amino amide type in different medicinal forms, such as vials, ampoules, ointments, sprays, and gels. By competing with calcium in sitting on nerve membrane receptors, this drug controls the passage of sodium through the cell membrane and reduces the depolarization phase of the action potential. These effects stop the initiation and conduction of nerve waves by reversibly stabilizing the membrane of nerve cells as a result of lessening the permeability of this membrane to sodium ions. If a large amount of lidocaine is absorbed, it can first have a stimulating effect and then a weakening effect on the central nervous system.

IV lidocaine is used in the treatment of cardiac arrhythmias, particularly ventricular arrhythmias. It is a Class 1-b anti-arrhythmic agent and is effective on phase zero of the cardiac cell action potential. Further, IV lidocaine slows the speed of electrical conduction throughout the conduction system of the myocardium. [3]

Although the mechanism of the effects of IV lidocaine on diminishing coughs and airway irritations is not fully known, some studies have stated the beneficial effects of IV lidocaine on the suppression of C-type sensory fibers by decreasing peripheral nerve discharges or by selectively reducing pain transmission in the spinal cord. [4-6]

Various studies have been conducted on the effects of IV lidocaine during extubation mostly after minor surgeries. Their results indicate that IV lidocaine is effective in lessening the incidence of coughs and laryngospasms after anesthesia, especially in head and neck, larynx, and nose surgeries. Previous research also shows that lidocaine is efficient in both intratracheal and IV modes 10 minutes before extubation with a dose of 1.5 mg/kg. [7]

In the cardiac surgery operating room, due to the major nature of the procedure, the type of anesthesia, and possible postoperative complications, the process of weaning and extubation is usually done step by step and with the frequent monitoring of the patient's respiratory and cardiac conditions through not only the

measurement of arterial gasses and the level of respiratory support but also chest X-rays taken in the ICU and generally within at least 4 hours after surgery.

Some evidence shows the effects of IV lidocaine on respiratory and cardiovascular responses following tracheal tube removal in the ICU after cardiac surgery. We conducted the current study to compare the effects of IV lidocaine with those of IV normal saline on reducing the incidence of coughs and sore throats, laryngospasms, and hemodynamic changes during tracheal extubation.

METHODS

The present double-blinded randomized clinical trial was conducted on 50 patients between 18 and 65 years of age who underwent heart surgery via a sternotomy within a 6-month period in 1400 in order to investigate the effects of IV lidocaine on reducing extubation complications after heart surgery in the ICU.

Patients were included in the study based on random blocks in 2 groups of 25: the IV lidocaine and IV normal saline groups.

Informed consent was obtained from all the patients before surgery in the preoperative visit regarding therapeutic interventions with lidocaine after extubation to reduce complications.

In both groups, patients who had the conditions of weaning and extubation within at least 4 to 12 postoperative hours were selected. The inclusion criterion was undergoing relatively simple heart surgeries, including coronary artery bypass grafting or single valve surgery. Patients with the amount of bleeding not requiring re-surgery and massive transfusion were also included in the study. Patients with dangerous arrhythmias and cardiac instability (receiving treatment with epinephrine or norepinephrine with a dose >1/. μ/kg), respiratory failure (PO_2 ≤60 mm Hg or pCO_2 ≥50), and a history of drug or alcohol addiction were excluded from the study. The type of anesthesia induced, anesthesia maintenance with propofol and fentanyl, and muscle relaxation with cisatracurium were the same in all the patients. Lidocaine was not injected after surgery. Sedation was achieved in both groups after consciousness and the evaluation of the motor response of all 4 limbs with a patient-controlled analgesia pump administering 400 μg of dexmedetomidine and 10 mg of morphine sulfate at a slow rate of 2 to 4 mL/h.

The pressure of the endotracheal tube cuff was checked as soon as the patient entered the special department (pressure =20-30 mm Hg). Finally, in both groups, the tracheal tube exit process was monitored with frequent blood and arterial gas checks and necessary wakefulness according to the routine open-heart ICU protocol. In the case group, 10 minutes before the removal of the tracheal tube and when the patient was breathing calmly in the spontaneous ventilator mode, 1.5 mL/kg of IV lidocaine 2% (Aburaihan Pharmaceutical Co, Iran) was injected. In the control group, 1.5 mL of IV normal saline was injected at the same time under the same conditions. The syringes containing lidocaine or normal saline were coded by a third person and given to the head of the nursing shift to be used randomly but at a specified time for the patients. Heart rate, blood pressure, and possible arrhythmias before and during the injection, 5 minutes after the injection, 1 minute after the endotracheal tube removal, and 10 minutes afterward were registered in a special form by the nurse in charge of the patient. At the time when patient was extubated, the following 3 cough criteria were recorded: [8]

Grade 1: no coughs or very short coughs at the time of extubation

Grade 2: coughing after the patient starts breathing

Grade 3: coughs before the patient starts breathing

Consciousness levels based on the Richmond Agitation-Sedation Scale (RASS) were recorded and analyzed 3 times before IV lidocaine injection, 1 minute afterward, and 10 minutes after tracheal tube removal. According to the presumption of taking β-blockers around the operation time, patients were excluded from the study if they were not taking β-blockers or were prohibited by the disease, such as patients with severe heart failure, due to the confounding effect.

Statistical Analysis

The data were analyzed using the statistical software SPSS, version 22.0, for Windows. Descriptive statistics, including measures of central tendency (mean ± standard deviation) and frequency distribution, were employed. For the statistical analysis of the results, the χ^2 and independent samples *t* tests were utilized. Within-group analyses of changes in continuous parameters at different time intervals were conducted using repeated measures ANOVA. A *P* value ≤ 0.05 was interpreted as statistically significant for all the tests.

RESULTS

Of the 50 patients included in our study, 7 patients due to excessive bleeding necessitating re-surgery and 2 patients with self-extubation were excluded. Forty-one patients were divided into 2 groups: the IV lidocaine group (n =21) and the IV normal saline group (n =20). The study population's demographic characteristics, type of surgery, a history of drug sensitivity, a history of arrhythmias, and a history of smoking are presented in Table 1. Additionally, the subjects' blood pressure, cough rates based on the RASS, sleepiness rates based on the RASS, PaO_2 and pCO_2 changes, and hemodynamic values and changes thereof are presented in Table 2 and Table 3.

No laryngospasms and sensitivities were found in any patient in either group. The rates of hemodynamic changes, including blood pressure and heart rate, and changes in blood gasses in the 2 groups were not statistically significant ($P \geq 0.005$). The changes in the level of consciousness based on the RASS were not significantly different between the 2 groups. The incidence of coughs based on the 3 criteria mentioned showed a significant difference between the lidocaine and normal saline groups (Table 3).

In the IV lidocaine group, 17 patients (81%) had grade 1 coughs, whereas 7 patients (35%) had grade 1 coughs in the IV normal saline group. Grade 2 coughs were reported in 11 patients (55%) in the placebo group and 4 patients in the IV lidocaine group. Grade 3 coughs were registered only for 2 patients in the IV normal saline group, constituting a statistically significant difference between the 2 groups (P =0.03).

Table 1: Comparisons of baseline characteristics between the study groups

	Placebo (n = 20)	Lidocaine (n = 21)	*P* value
Sex			0.27
female	8 (40%)	5 (24%)	
male	12 (60%)	16 (76%)	
Age, y	59 ± 9.6	53 ± 14.0	0.14
Surgery Type			0.34
CABG	16 (80%)	14 (67%)	
Valve	4 (20%)	7 (33%)	
History of Smoking			0.68
Yes	2 (10%)	3 (14%)	
History of Allergies			0.14
Yes	2 (10%)	0 (0%)	
History of Arrhythmias			0.38

Yes	2 (10%)	4 (20%)	
History of Pulmonary Diseases			0.95
Yes	3 (15%)	3 (14%)	
History of DM			0.65
Yes	6 (30%)	5 (24%)	
History of HTN			0.66
Yes	13 (65%)	15 (71%)	
History of Lidocaine Allergies			
Yes	0	0	

CABG, Coronary artery bypass grafting; DM, Diabetes mellitus; HTN, Hypertension

Table 2: Comparisons of hemodynamic indices between the study groups

	Placebo (n = 20)	Lidocaine (n = 21)	*P* value
BP1, mm Hg	66.5 (55.25 - 76.5)	66 (59 - 73)	0.886
Bp2	69.5 (59.25 - 78)	75 (62 - 78)	0.958
Bp3	70 (52.25 - 79.25)	70 (59.5 - 75)	0.723
P value (within-group changes)	<0.001	<0.001	
HR1, bpm	86.5 (60.5 - 97.75)	76 (63.5 - 90)	0.426
HR2	98 (81.75 - 113.75)	80 (68.5 - 95)	0.014
HR3	89.5 (72 - 99.5)	75 (62.5 - 90)	0.086
P value (within-group changes)	<0.001	<0.001	
PaO_2-1, mm Hg	114 (99 - 153.75)	114 (99.5 - 157)	0.886
$PaO^{2-}2$	100 (91.25 - 110)	98 (92.5 - 145)	0.814
P value (within-group changes)	<0.001	<0.001	
pCO_2-1, mm Hg	38 (31.5 - 44)	39 (33 - 48)	0.388
pCO_2-2	36 (33 - 45.5)	41 (36 - 48.5)	0.071
P value (within-group changes)	<0.001	<0.001	

- BP, Blood pressure; HR, Heart rate; 1, Just before injection; 2, 1 minute after injection; 3, 10 minutes after injection; PaO_2, Arterial oxygen pressure; pCO_2 , Partial pressure of carbon dioxide; 1, Just before injection; 2, 10 minutes after injection

Table 3: Incidence of study end-points in the study groups

	Placebo (n = 20)	Lidocaine (n = 21)	*P* value
Coughs			0.03
1: no coughs or very short coughs at the time of extubation	7 (35%)	17 (81%)	
2 :Coughing after normal breathing	11 (55%)	4 (19%)	
3: Occurrence of coughs before the patient breathes	2 (10%)	0 (0%)	
Arrhythmias			0.11
Yes	3 (15%)	0 (0%)	
Richmond Agitation-Sedation Scale (RASS)			
RASS1(before extubation)			0.26
-2	1 (5%)	4 (19%)	
-1	2 (10%)	3 (14%)	
0	13 (65%)	10 (48%)	
1	2 (10%)	4 (19%)	
2	2 (10%)	0 (0%)	
RASS2 (10 min after extubation)			0.27
-2	2 (10%)	1 (5%)	
-1	2 (10%)	3 (14%)	
0	13 (65%)	9 (43%)	
1	2 (10%)	8 (38%)	
2	1 (5%)	0 (0%)	
P value (within-group changes)	0.10	0.02	

DISCUSSION

The prevention of tachycardia, increased blood pressure, and coughs after cardiac surgeries is crucial since they can affect the surgical results. One of the most significant challenges for cardiac anesthesiologists in the ICU is timely and calm extubation based on surgical ICU protocols. The use of lidocaine before removing the tracheal tube can confer smooth extubation.

In a systematic review by Stephen et al [7] in 2020 on 16 trials and different surgeries, coughs and sore throats were reduced in 14 trials (931 patients) after IV lidocaine injection compared with a placebo. Five studies with a total population of 450 patients reported a statistically significant difference concerning the rate of cough reduction between a low dose of lidocaine (1-0.5 mL/kg) and a high dose of lidocaine (1.5-2 mL/kg). Six trials with a total population of 349 patients showed that injectable lidocaine did not lead to a statistically significant difference in the occurrence of laryngospasms.

In a study conducted in 1991 by Paulissian et al [9] on 25 patients undergoing usual heart surgery procedures and receiving pulmonary catheters in the Heart Anesthesia Department of Illinois Hospital in Chicago, relevant information was recorded 5 minutes before extubation, just before suction, immediately after extubation, and 5 and 20 minutes afterward. Hemodynamic indicators, such as blood pressure, heart rate, venous pressure, cardiac index, and pulmonary wedge pressure, did not change much. The authors concluded that this lack of success was due to β-adrenergic system suppressor drugs consumed around and on the morning of the surgery. Moreover, lidocaine with a higher dose (1.5-2 mL/weight) controlled cough reflexes.

In our study, regarding changes in blood pressure and hemodynamics, although they seemed relatively stable numerically in the IV lidocaine group, the difference between the case and control groups failed to constitute statistical significance, which could be due to the complex and multifactorial mechanisms of blood pressure and heart rate. Owing to the extensive use of β-blockers and angiotensin-blocker drugs around the operation, these changes were not statistically significant (fig 1).

Aljonaieh et al [10] in 2018 performed a study on 72 patients undergoing laparoscopic cholecystectomy. In their investigation, lidocaine was injected before the end of the surgery and just when desflurane was stopped. In their 2 study groups, coughs and laryngospasms were evaluated and scored as follows: 0, completely normal; 1, partial vocal cord obstruction and slight stridor; 2, complete vocal cord obstruction without cyanosis; and 3, complete obstruction and cyanosis. The authors concluded that lidocaine with a dose of 1 mL/kg was effective against coughs and laryngospasms after extubation in the operating room.

George et al [8] assessed 114 patients undergoing elective craniotomy with lidocaine injection (1 mL/kg) and compared them with a control group receiving a placebo injection. They evaluated the 2 groups vis-à-vis hemodynamic changes and the occurrence of coughs after extubation in the operating room. They drew upon the same criteria as we did in our study.

In their study, the drug test was done 20 to 30 minutes before the end of the surgery when the head pins were removed. The authors measured the blood level of the drug in the groups after the intervention and found a significant difference between the injections: only IV lidocaine injection was statistically significantly effective in terms of reducing coughs after extubation. We based our statistical analysis on the 2 aforementioned studies.

In our study, the decrease in the grades of cough incidence before extubation was

statistically more significant in the IV lidocaine group than in the IV normal saline group.

Shabnum et al [11] evaluated 60 patients undergoing craniotomy and reported a reduction in hemodynamic changes and the incidence of coughs with IV lidocaine injection compared with a placebo without any change in the level of consciousness. Their findings regarding a noticeable change in the level of consciousness are similar to our study (fig 3).

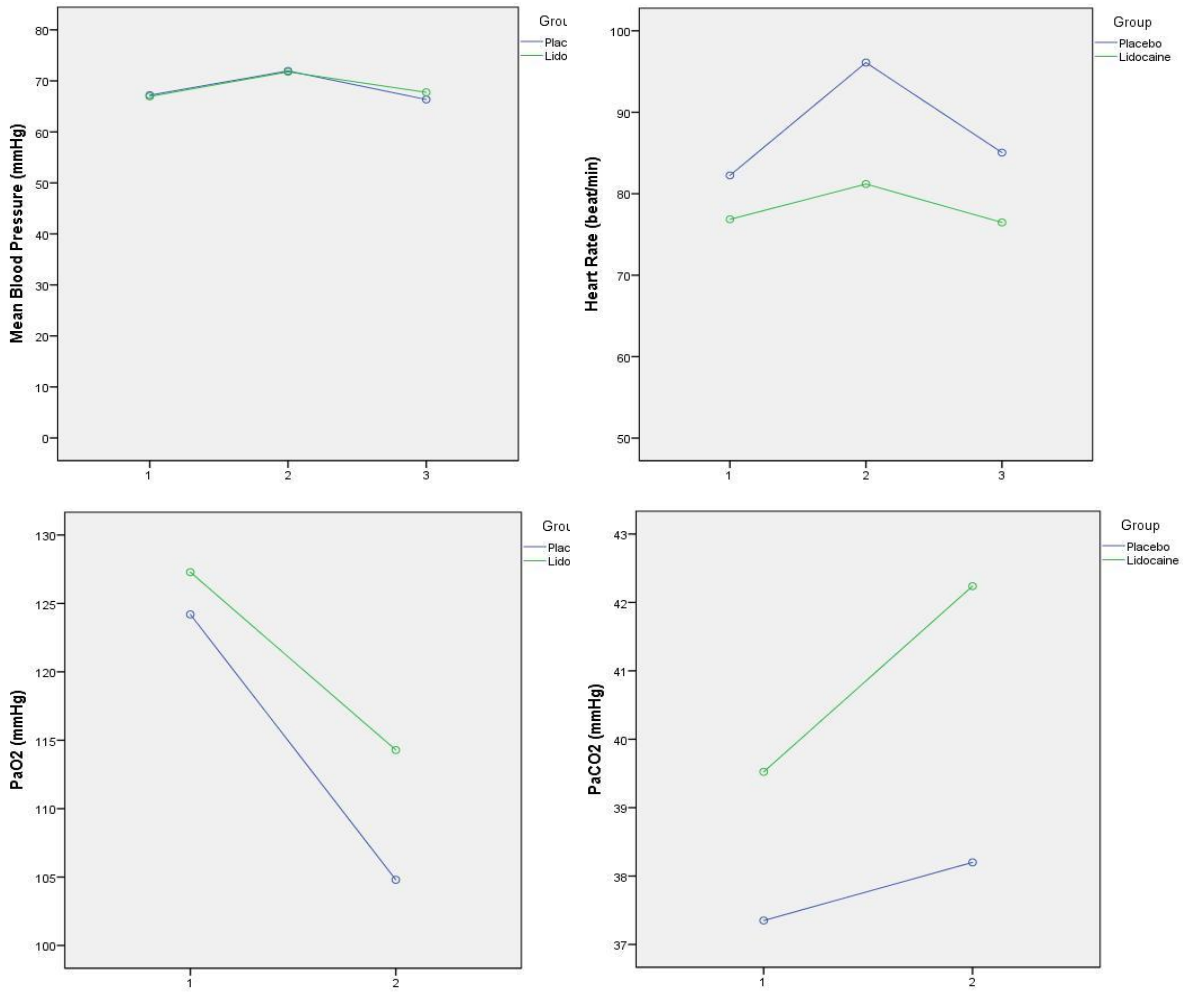

Figure 1: The images present hemodynamic indices: a) mean arterial pressure, b) heart rate, c) O_2 pressure, and d) CO_2 pressure.

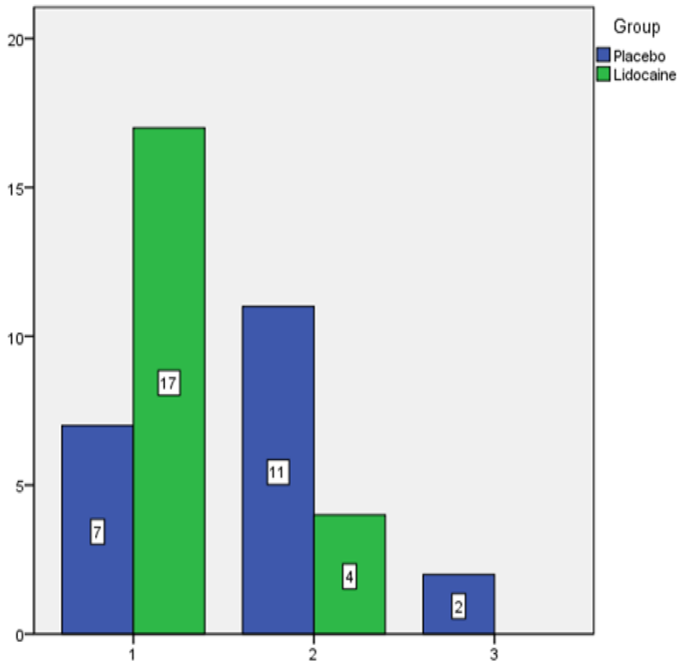

Figure 2: The image presents the 3 cough criteria between the 2 study groups: Grade 1: no coughs or very short coughs at the time of extubation; Grade 2: coughing after normal breathing; Grade 3: occurrence of coughs before the patient breathes.

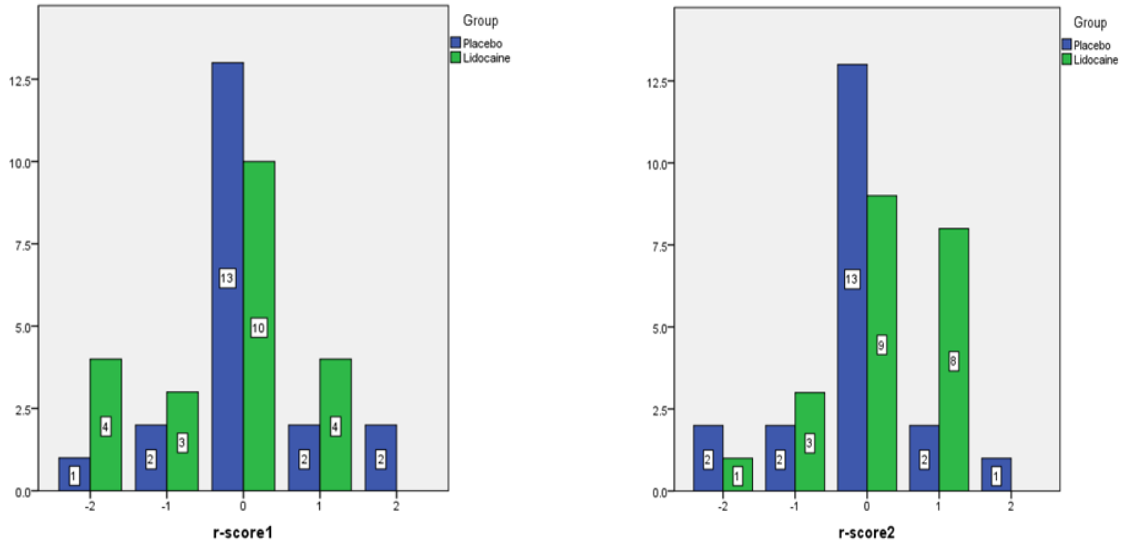

Figure 3: The images depict the Richmond Agitation-Sedation Scale (between -5 and +5).

CONCLUSIONS

Lidocaine can be routinely used in the ICU, as is used for tracheal tube removal in the operating room after minor surgeries, following cardiac surgery as part of the weaning and extubation process to reduce complications, such as coughs and sore throats.

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