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Use of Dexmedetomidine to Facilitate Extubation of Patients after Coronary Artery Bypass Surgery

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Abstract

Introduction: Given that extubation after coronary artery bypass surgery has always been controversial, the aim of this study was to use different doses of dexmedetomidine (0.3 and 0.7 mg/kg) to facilitate extubation of patients after coronary artery bypass surgery.

Method and Materials: A total of 78 patients of ASA classes II and III, who were candidates for coronary artery bypass surgery, were studied during the period from 2016 to 2017. Patients were divided into three groups, including the control group, and the two groups receiving 0.3 and 0.7 mg per kg body weight doses of dexmedetomidine. All of the collected variables, which consisted of three parts including: demographic, recovery, and hemodynamic information, were completely measured and analyzed.

Result: The results were indicative of a higher preinduction arterial blood pressure level in the control group than in the groups receiving doses of dexmedetomidine ($P < 0.05$). The use of dexmedetomidine in patients having undergone coronary artery bypass surgery did not show a significant effect on their heartbeat rates ($P < 0.05$). Only four hours after the admission of the patient to the ICU, the cardiac index rate showed a significant increase with the increased dose of dexmedetomidine compared with that in the control group ($P < 0.05$). The use of a 0.7 mg/kg dose of dexmedetomidine significantly decreased the time taken to remove the tracheal tube compared with that in the control treatment ($P < 0.05$). The time taken to discharge the patients from the ICU was significantly decreased in the groups receiving dexmedetomidine compared with that in the control group.

Concelusion: The results of this study showed that in the fast-track recovery of patients with coronary artery bypass surgery, dexmedetomidine was an appropriate drug for maintaining anesthesia, and provided good hemodynamic stability.

Keywords: Coronary Artery Bypass Surgery, Extubation, Dexmedetomidine

Introduction

Coronary artery disease (CAD) is one of the most common cardiac disorders, which causes many deaths annually. The treatment and control of this disease and the disablement due to it impose a high cost on society (1). In this disease, the entire coronary artery canal or part of it is narrowed and/or obstructed due to atherosclerosis, spasms, or presence of thrombi (blood clots). Consequently, the affected artery will not be able to meet the needs of myocardial muscle for oxygen and nutrients. And finally, angina pectoris and myocardial infarction will occur (2). One of the medical procedures for treating this disease is coronary artery bypass surgery. In coronary artery bypass surgery, a bypass is created for the obstructed coronary artery through grafting some veins between the points before and after the narrowed path, which re-establishes the coronary blood flow into the affected area. In another technique, reperfusion is established in the coronary artery through transplantation between the internal mammary artery and the coronary artery (3). After coronary bypass surgery, it is necessary to maintain appropriate mechanical ventilation, sufficient oxygenation, and hemodynamic stability. The patient's separation from the mechanical ventilation device and the extubation of the tracheal tube or pulmonary artery catheters are performed in the next step (4). Extubation of the tracheal tube, if performed as soon as possible, will reduce the costs of treatment (the costs of nursing and the intensive care unit (ICU)) (5). The rapid extubation of patients after

heart surgery has other benefits too, out of which we can refer to: patients' comfort, reduced respiratory complications,easy control of patients, patients' ability to walk sooner, and the facilitation of performing activities(6). Sometimes, patients need sedatives and painkillers after surgery. The desired drugs may affect the respiratory system, and cause some problems in the initial extubation(7). One of the techniques making extubation possible is use of an appropriate sedative agent called dexmedetomidine, which has no harmful effects on the respiratory system, and which is introduced as a substitute for sedative regimens(8). Dexmedetomidine is a selective α_2-adrenergic receptor agonist, which has analgesic and sedative effects, and which has no adverse effects on the respiratory system (9). Dexmedetomidine has been studied in terms of facilitating extubation in patients after heart surgery (7), in the ICU (8), and in terms of renal function (10). Dexmedetomidine provides the patient with hemodynamic stability(11). Dexmedetomidine has unique sedative properties. Its consumption only causes a mild cognitive disorder, which helps facilitate establishment of communication between health-care services and the patient(12). It also has some positive effects on myocardial oxygen supply, cardiac oxygen demand, and consequently on myocardial protection(13). The protective effects of dexmedetomidine on post-operative cardiac injuries have been confirmed (14, 15). Moreover, with dexmedetomidine being used, reduced consumption of sedative substances and greater analgesia have been reported (14). Doering et al. conducted an investigation on pre-, peri- and postoperative predictors for rapid and delayed extubation of patients undergoing coronary artery bypass surgery. In this study, most patients with delayed extubation were over 70 years old. Therefore, age could be one of the factors affecting extubation(16) . Cardiac reserve decreases in the elderly, thus increasing the incidence of chronic diseases such as heart failure, kidney diseases, and hypertension. On the other hand, their decreased health capacity and physical vigor may affect postoperative recovery and duration of intubation(17) . This is while Arom et al. emphasized that there were no relationships between age and time of extubation (18). Gupta et al. used different doses of dexmedetomidine (0.2-0.7 mg/kg) for early extubation in ICU patients (8). Given that the effects of different doses of dexmedetomidine on extubation have not been studied in patients undergoing coronary artery bypass surgery, in this study, we decided to investigate the effect of dexmedetomidine on the timing of extubation in patients undergoing coronary artery bypass surgery. To this end, we studied the effects of four different doses of dexmedetomidine on sedative properties, cardiovascular responses, respiratory status, and extubation and immune characteristics in patients undergoing coronary artery bypass surgery.

Materials and Methods

The Studied Patients

The present study was conducted in a cross-sectional manner in one of the specialty heart hospitals in Tehran. A total of 78 patients of ASA (American Society of Anesthesiologists) classes II and III, who were candidates for coronary artery bypass surgery, were studied during the period from 2016 to 2017. After some administrative correspondence, written consent was obtained from the patients, and a commitment was made to respect the confidentiality of their information. Patients, who had valvular disorders and/or showed paraclinical symptoms of impaired renal function, were excluded from the study. Accordingly, 78 patients, who were candidates for coronary artery bypass surgery, underwent the study. The patients were divided into three groups of 26. The control group included patients, to whom 0.9% saline was administered using an infusion pump. The second and third groups received 0.3 and 0.7 mg per kg body weight doses of dexmedetomidine, respectively.

In all patients, surgery was performed through median sternotomy and using a cardiopulmonary pump. In cardiopulmonary bypass (CPB), the patients' temperature was reduced down to 32 °C, and a cold potassium-rich Ringer's solution was used as a cardioplegia solution. Immediately after completion of surgery, the anesthetist technician transferred all patients from the operating room to the open-heart surgery ICU, located adjacent to the operating room, and handed them over to the nurse in charge of the patients. Morphine was administered at a dose of 3 mg and in an infusion form to relieve postoperative pain. The nurse regularly monitored the time of opening the eye and the response to the sound every fifteen minutes. With the patient beginning to breathe, if having normal body temperature, not having internal and mediastinum bleeding higher than 100 cc/h, and having constant and stable hemodynamics, the nurse would gradually weaned them from the ventilator. And if the patient completely woke up and obeyed the commands, if they had a respiratory rate of less than 20 times per minute, if blood gases were normal, if there were no signs of arrhythmia, and if the patient did not receive any inotrope agents at a dose higher than 5 mg/kg, the tracheal tube would be removed. Neostigmine and atropine were administered intravenously to recover the patients' muscle flexibility.

The Measured Parameters

All of the collected variables, which consisted of three parts including: demographic, recovery, and hemodynamic information, were completely measured and analyzed. Demographic information was extracted from the nursing and medical records contained in the patients' records. Hemodynamic parameters including: arterial blood pressure (mmHg), heartbeat rate, cardiac index, and arterial oxygen saturation (percent) were measured before induction of anesthesia, five minutes after induction, before aortic convulsions, upon admission to the ICU, and four hours after admission to the ICU. During caregiving, the relevant nurse also monitored and recorded recovery characteristics including: extubation (removal of the tracheal tube) (hours), discharge from the ICU (hours), the visual response (minutes), and the auditory response.

Statistical Analysis

First, the descriptive statistics of the data, including the frequency, mean, maximum, and minimum of the demographic information were calculated. Then, an analysis of variance (ANOVA) was performed to investigate the effect of dexmedetomidine on the measured parameters. The number of treatments was three, including the control group, and the two groups receiving two different doses of dexmedetomidine. To this end, a completely randomized design was used with the aid of SAS software. The mean values of the parameters were compared through Duncan's multiple range test at a probability level of 5%.

Results

Table 1 provides the descriptive statistics of the demographic characteristics of patients present in this study. Out of the 78 studied patients, who were undergoing coronary artery bypass surgery, 45 were male patients (57.7%), and 33 female patients (42.3%). The mean age was greater in the control group (64 years) than in the groups receiving dexmedetomidine (61.6 and 62.3 years). The mean weights, calculated separately by groups, were 72.9, 71.8, and 71.4 kg in the control group and the two groups receiving 0.3 and 0.7 mg/kg doses of dexmedetomidine, respectively. The mean body surface area was calculated to be 1.92 square meters in all patients investigated in this study.

Table 1: The demographic information of the studied patients

Variable	Control group	The group of dexmedetomidine 0.3	The group of dexmedetomidine 0.7
Age (years)	64	61.6	62.3
Gender (male/female)	(15.11)	(13.13)	(17.9)
Weight (kg)	72.9	71.8	71.4
Body surface area (m^2)	1.94	1.90	1.92

Based on a review of their clinical records, 19.2% of the patients had a history of hypertension. It should also be noted that 30.7% of the patients were smokers, out of whom 57% had a history of smoking, but had not smoked for more than three years. Meanwhile, there were no significant relationships between the three groups in terms of tobacco use.

Table 2 shows results obtained from comparing mean hemodynamic parameters including: arterial blood pressure, heartbeat rate, cardiac index, and arterial oxygen saturation before induction, after induction, after coronary artery bypass surgery, upon admission to the ICU, and four hours after admission to the ICU. The preinduction arterial blood pressure level was higher in the control group than in the groups receiving doses of dexmedetomidine. The mean preinduction arterial blood pressure was significantly higher in the control group than in the other groups. It was not significantly different from that in the group of dexmedetomidine 0.3, but it was significantly different from that in the group of dexmedetomidine 0.7 ($P < 0.05$). After induction, arterial blood pressure was higher in the control group than in the groups receiving dexmedetomidine ($P < 0.05$). There were no significant differences between the control group and the groups receiving dexmedetomidine after coronary artery bypass surgery, upon admission to the ICU, and four hours after admission to the ICU. The use of dexmedetomidine in patients having undergone coronary artery bypass surgery did not show a significant effect on their heartbeat rates ($P < 0.05$), even though the heartbeat rate was lower in the groups receiving dexmedetomidine than in the control group.

Table 2: The patients' hemodynamic parameters separated by groups

Parameter	Group*	Before induction	After induction	After coronary artery bypass surgery	Upon admission to the ICU	4 hours after admission to the ICU
Arterial blood pressure (mmHg)	Control	90.3a**	87.3a	90.1a	91.1a	87.4a
	0.3	89.7a	85.9b	89.4a	88.7a	87.7a
	0.7	88.6b	86.2c	88.5a	89.6a	88.6a
Heartbeat rate	Control	74a	69a	60a	65a	71a
	0.3	65a	67a	62a	64a	71a
	0.7	63a	65a	59a	63a	69a
Cardiac index	Control	2.7a	2.4a	2.3a	2.5a	2.6b
	0.3	2.6a	2.5a	2.3a	2.6a	2.7b
	0.7	2.6a	2.4a	2.2b	2.6a	2.8a
Arterial oxygen saturation (%)	Control	95.4a	88.6b	90.2a	90.4a	91.3b
	0.3	95.6a	90.7a	91.7a	91.1a	92.6a
	0.7	96.2a	90.2a	91.2a	91.3a	93.2a

* Three groups, including: control, dexmedetomidine 0.3, and dexmedetomidine 0.7

** Similar letters represent non-significance, and dissimilar letters represent significance at a level of 5%

The cardiac index did not show a clear and significant trend of changes after the use of different doses of dexmedetomidine. Only four hours after the admission of the patient to the ICU, the cardiac index rate showed a significant increase with the increased dose of dexmedetomidine compared with that in the control group ($P < 0.05$). The use of medication has not had a significant effect on the arterial oxygen saturation rate (Table 2). The only difference in the mean values occurred after induction and four hours after admission to the ICU, when the use of dexmedetomidine significantly increased arterial oxygen saturation ($P < 0.05$).

Figures 1 and 2 provide results obtained from comparing the mean parameters measured at the stage of the recovery of the patients, who were candidates for coronary artery bypass surgery, including: tracheal extubation, the visual and gustatory responses, and discharge from the ICU.

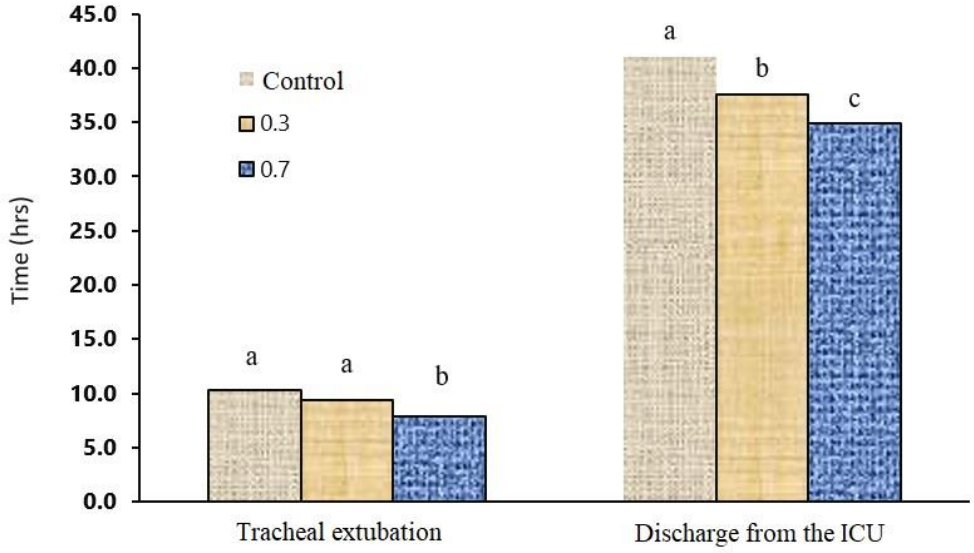

Figure 1: A comparison between the mean values of the parameters: discharge from the ICU and tracheal extubation, in the different studied groups (including the control group, the group of dexmedetomidine 0.3, and the group of dexmedetomidine 0.7)

The time taken to remove the tracheal tube (hours) was higher in the control group than in the groups receiving doses of dexmedetomidine (Fig. 1). In the group having received a 0.3 mg/kg dose of dexmedetomidine, the tracheal extubation time decreased by 8.8% in comparison with that in the control group, which was not significant ($P > 0.05$). This is while the use of a 0.7 mg/kg dose of dexmedetomidine significantly decreased the time taken to remove the tracheal tube. It should be noted that infusion of dexmedetomidine significantly reduced the time taken to discharge the patients from the ICU. There was also a significant difference between the results obtained from the two different doses of dexmedetomidine ($P < 0.05$).

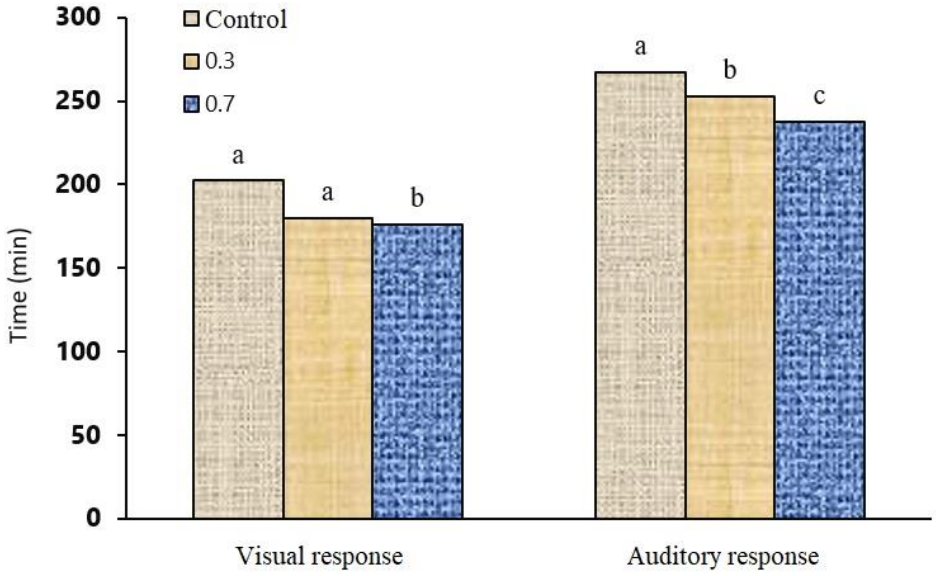

Figure 2: A comparison between the mean values of the parameters: the visual and auditory responses, in the different studied groups (including the control group, the group of dexmedetomidine 0.3, and the group of dexmedetomidine 0.7)

As shown in Fig. 2, dexmedetomidine improved the patient's visual response. However, while there were no significant differences between the group of dexmedetomidine 0.3 and the control group in terms of their visual responses, the group receiving dexmedetomidine 0.7 showed a significant difference from the control group. No significant differences were observed between the results obtained from the two different doses of dexmedetomidine ($P > 0.05$). The auditory response time was reduced due to the consumption of dexmedetomidine, which was statistically significant in comparison with that in the control group. The minimum mean auditory response time belonged to the group receiving the 0.7 mg/kg dose of dexmedetomidine.

Discussion

In our study, arterial blood pressure decreased due to the use of dexmedetomidine, which was consistent with results obtained by other researchers. Patel et al investigated the effect of dexmedetomidine infusion on stress responses during intubation and during surgery. They showed that use of dexmedetomidine reduced the heartbeat rate and the systolic and diastolic blood pressure levels in comparison with those in the control group(19). In our study, we also showed that the heartbeat rate decreased in the group receiving dexmedetomidine compared with that in the control group, which was consistent with results obtained byVenn et al(19). reported a lower heartbeat rate ($P < 0.05$) in the groups receiving dexmedetomidine. This is while no significant differences were observed between the groups receiving dexmedetomidine and the control group in terms of their arterial blood pressure levels(11, 20). reported that use of dexmedetomidine resulted in a decrease in the systolic blood pressure level as well as a decrease of 21% in the heartbeat rate during the first four hours. Arpino et al. showed that after infusion of dexmedetomidine, the heartbeat rate decreased in most patients, and addition of dexmedetomidine was associated with minimal changes in the mean arterial blood pressure(21). In our study, during periods after induction and four hours after admission to the ICU, the mean level of arterial oxygen saturation was significantly higher compared with that in the control group, which was consistent with results obtained by Gupta et al. (8). In their study, Bakhamees et al. reported greater hemodynamic stability, lower

consumption of sedatives, and greater analgesia in obese patients with laparoscopic gastric bypass surgery in the dexmedetomidine group than in the control group(14).

An ideal drug for sedation in the ICU is a drug that provides sedation without affecting the cardiovascular and respiratory systems. The intended drug must have a low half-life, must not be accumulated, and must be metabolized by a pathway that is not dependent on renal, hepatic, or pulmonary function (22). It seems that dexmedetomidine can provide appropriate drug properties due to its effects in reducing the time taken to discharge the patient from the ICU. In addition, use of dexmedetomidine reduced the time taken to remove the tracheal tube. On the other hand, other studies have reported hemodynamic stability during tracheal extubation in patients undergoing surgery with dexmedetomidine(19).

Prolonged use of mechanical ventilation increases the mortality rate. A nurse in the heart surgery ICU, has to continuously examine the patients in terms of complications associated with mechanical ventilation(23). Hence, by reducing the time taken to remove the tracheal tube, dexmedetomidine improves recovery, and reduces complications resulting from late tracheal extubation in patients. Meanwhile, rapid extubation makes the patient suffer from disorders in the acid-base balance and oxygenation, which causes respiratory distress and intolerance in the patient in the continuation of the weaning process. Thus, the continuation of this process must be avoided, and the patient must be connected to the ventilator (24). But infusion of dexmedetomidine, while maintaining hemodynamic stability, causes tracheal extubation to be carried out sooner in comparison with that in the control group.

Conclusion

In the fast-track recovery of patients with coronary artery bypass surgery, dexmedetomidine was an appropriate drug for maintaining anesthesia, and provided good hemodynamic stability. Given that no significant differences were observed between the 0.3 and 0.7 mg doses of dexmedetomidine in patients, it seems that use of its lower dose will have a better efficacy in terms of the cost-benefit analysis of this medicine. Since none of the patients in the dexmedetomidine groups had been affected by probable complications, had not needed re-intubation, and yet showed stable hemodynamics, it could be said that early extubation would be safe and away from any danger in the patients of these groups. Therefore, due to the short time taken to remove the tracheal tube when using dexmedetomidine, it can be concluded that dexmedetomidine is clinically beneficial in facilitating extubation. Most of the subjects had good clinical status, and were not faced with the risk factors of prolonged intubation. The sample size was small in this study. In addition, in order to control interventional variables, this study was conducted only on patients undergoing surgery at one medical center and under a constant surgical, anesthesia, and nursing team. Hence, for a more careful examination, it is suggested that these variables be studied again with a larger sample size and/or using a control test, and that they also be examined in other open heart surgery operations in order to achieve further generalizability.

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