e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2024; 16(1); 865-870

Original Research Article

Comparative Study to Evaluate the Attenuation of Hemodynamic Response to Laryngoscopy and Endotracheal Intubation using Nebulised Lignocaine and Intravenous Lignocaine

Anuradha Gajraj[1], Ruhani Arora[2], Rishabh Aggarwal[3], Sanjeev Kumar[4*], Vibha Mehta[5], Jyoti Sharma[6]

[1]Senior Resident, Dept of Critical Care Medicine, Holy Family Hospital, Okhla, New Delhi, Karnal, India
[2]Senior Resident, Dept of Anaesthesia, Kalpana Chawla Govt Medical College, Karnal, India
[3]Assistant Professor, Dept of Anaesthesia, Maharaja Agrasen Medical College, Agroha, Hisar, India
[4]Professor, Dept of Anaesthesia, Maharaja Agrasen Medical College, Agroha, Hisar, India
[5]Professor, Dept of Anaesthesia, Maharaja Agrasen Medical College, Agroha, Hisar, India
[6]Associate Professor, Dept of Anaesthesia, Maharaja Agrasen Medical College, Agroha, Hisar, India

Received: 17-11-2023 / Revised: 13-12-2023 / Accepted: 29-12-2023
Corresponding Author: Dr Sanjeev Kumar
Conflict of interest: Nil

Abstract:

Background and Aims: Laryngoscopy and endotracheal intubation are potent stimuli that can induce increased sympathetic activity leading to tachycardia, hypertension and dysrhythmias and increased levels of circulating catecholamines. Different drugs and methods have been proposed to relieve such stimulation induced responses. However, no apparent consensus has been reached as to which method is ideal in attenuation of these hemodynamic reflexes. Intravenous lignocaine is effective in controlling the haemodynamic response to laryngeal manipulations. [36]Very few studies have been done to find the effect of nebulised lignocaine on hemodynamic response to airway manipulation. So we decided to compare the effect of nebulised lignocaine and intravenous lignocaine in attenuation of hemodynamic response to laryngoscopy and endotracheal intubation.

Material and Method: 100 ASA class I or II patients scheduled for elective surgeries under GA requiring endotracheal intubation randomized into two groups. Group A (N=50) patients were nebulised with 2% lignocaine in dose of 2 mg per kg body weight. Group B (n=50):2% lignocaine in dose of 2 mg per kg body weight injected intravenously two minutes before induction. Intravenous induction was done with thiopentone 5mg/kg. Muscle relaxation was achieved with injection vecuronium bromide 0.1 mg/kg i.v. The patient was ventilated with oxygen and nitrous oxide (50:50) and 0.8% of isoflurane, followed 3 minutes later by laryngoscopy and endotracheal intubation by oral cuffed endotracheal tube, of duration less than 30 seconds. Laryngoscopy was done using Macintosh laryngoscopic blade. Endotracheal intubation was done using standard anaesthetic technique for insertion in sniffing position. After the performance of the study, anaesthesia was maintained using 0.8% of isoflurane in oxygen (50%) and nitrous oxide (50%). Hemodynamic parameters (HR, SBP, DBP, MAP) were recorded at various intervals. The comparison of normally distributed continuous variables between the groups was performed using Student's t test. To determine the significant change at different time points from baseline within the groups were performed using Paired t test.$p<0.05$ was considered statistically significant.

Results: Heart rate decreased after induction in both the groups. The increase in heart rate observed during laryngoscopy and intubation(T0) was more profound in Group Bas compared to Group A. Heart rate attained its baseline at 3 min(T3) in Group A and was significantly lower at 5 and 15 min as compared to Group B. The increase in SBP, DBP and MAP observed during laryngoscopy and intubation(T0) was more profound in Group B as compared to Group A. SBP, DBP and MAP attained its baseline at 3 min(T3) in Group A and was significantly lower at 5 and 15 min as compared to Group B.

Conclusions: Nebulisation with lignocaine is an easy, cost-efficient and better approach to attenuate the hemodynamic response rather than intravenous lignocaine.

Keywords: Lignocaine, Hemodynamic response, Nebulisation.

Introduction

The circulatory response to laryngoscopy and endotracheal intubation was first described by King in 1951. [1] It may have deleterious respiratory, neurological and cardiovascular effects. It has been observed that these responses are more marked in hypertensive patients, in patients with coronary artery disease, leaking abdominal aneurysm, intracranial aneurysm and recent myocardialinfarction.Thesetransientchangescanresultinpotentiallydeleteriouseffectssuch as myocardial ischemia, left ventricular failure (as a result of increased myocardial oxygen demand) and cerebral hemorrhage. [2,3] Hence an anaesthetic induction technique is needed which is not associated with increased sympathetic response to laryngoscopy and tracheal intubation.

Different drugs and methods have been proposed to relieve such stimulation induced responses. Commonly used techniques include increasing depth of anesthesia by heavy premedication, use of potent narcotics such as fentanyl, [4] alfentanil, [5] remifentanil [6] and inhalational anesthetic agents like halothane. [7] However, no apparent consensus has been reached as to which method is ideal in attenuation of these hemodynamic reflexes.

Intravenous lignocaine is effective in controlling the haemodynamic response to laryngeal manipulations. [8] On the other hand, nebulised lignocaine has been used to treat bronchial asthma. [9] Very few studies have been done to find the effect of nebulised lignocaine on hemodynamic response to airway manipulation and have found that its efficacy is similar to other regional techniques. [10-12] Lignocaine is used both intravenously and in nebulised form to decrease the heart rate and blood pressure. So we decided to compare the effect of nebulised lignocaine and intravenous lignocaine in attenuation of hemodynamic response to laryngoscopy and endotracheal intubation.

Materials and Methods

One hundred normotensive patients of either sex, aged between 18-60 years, weight ranging from 45-60 kg, belonging to American Society of Anesthesiologists (ASA) physical status I or II scheduled for elective surgical procedure under general anaesthesia requiring endotracheal intubation were enrolled for the study. Patient with anticipated difficult airway, heart rate less than 50 beats per minute, heart block, hypertension, coronary artery disease, left ventricular dysfunction, patient on drug causing hemodynamic instability, laryngoscopy time more than 30 seconds, allergic tolignocaine, pregnant and lactating mothers were excluded from the study.

Patients randomly allocated to two groups comprising of 50 patients each using sealed envelopes which randomly distributed by the staff nurse. Patient induced by the fellow anesthetist and readings noted down by the candidate who is blind to the study drug and group allocated to the patient.

Group A (n=50): patients were nebulised with 2%lignocaine in dose of 2 mg per kg body weight using a simple fitting face mask and nebulised over 15 minutes before induction.

Group B (n=50):2% lignocaine in dose of 2 mg per kg body weight injected intravenously two minutes before induction.

All the patients were pre-medicated with injection midazolam 0.02 mg/kg and injection fentanyl 2 mcg/kg 20 minutes before induction, group A patients were nebulised over 15 minutes whereas group B patients injected with 2% lignocaine 2 minutes before induction. After pre oxygenating with 100% oxygen intravenous induction was done with thiopentone 5mg/kg. Muscle relaxation was achieved with injection vecuronium bromide 0.1 mg/kg i.v. The patient was ventilated with oxygen and nitrous oxide (50:50) and 0.8% of isoflurane, followed 3 minutes later by laryngoscopy and endotracheal intubation by oral cuffed endotracheal tube, of duration less than 30 seconds.

Laryngoscopy was done using Macintosh laryngoscopicblade. Endotracheal intubation was done using standard anaesthetic technique for insertion in sniffing position. Cuff was inflated and correct placement of endotracheal tube was judged by adequate chest rise, bilateral chest auscultation and capnography using manual positive pressure ventilation. The endotracheal tube was fixed and connected to anaesthesia breathing circuit. After the performance of the study, anaesthesia was maintained using 0.8% of isoflurane in oxygen (50%) and nitrous oxide (50%). Patient was mechanically ventilated with tidal volume 8-10 ml/kg and respiratory rate 12/minute. At the end of the surgery patient was neuro-muscularly reversed and extubated. Side effects if any were noted and managed accordingly.

Concomitantly blood pressure (Systolic, Diastolic and Mean Blood Pressure) via noninvasive blood pressure monitoring and heart rate through continuous ECG monitoring recorded at pre induction (baseline), after giving the study drug, post induction, during laryngoscopy and intubation and 1,3,5 and 15 minutes after laryngoscopy and intubation in both groups. Duration of laryngoscopy was recorded using stopwatch. In case of bradycardia patient was treated with injection atropine 0.6mg i.v. bolus and any episode of hypotension was treated with injection mephenteramine 3mg i.v. bolus with aim to keep blood pressure within 20% of base line.

Statistical testing was conducted with the statistical package for the social science system version SPSS 28.0(Chicago, IL, USA). Results are expressed as mean ± SD or numbers and percentages. The comparison of normally distributed continuous variables between the groups was performed using Student's t test. To determine the significant change at different time points from baseline within the groups were performed using Paired t test. $p<0.05$ was considered statistically significant.

Results

Table 1: Comparison of age and weight and laryngoscopy time between Group A and Group B

	Group A	Group B	p value
	Mean ± SD	Mean ± SD	
Age	33.56 ± 7.608	37 ± 11.916	0.088
Wt.	54.24 ± 6.317	56.04 ± 4.262	0.098
Laryngoscopy Time (sec.)	11.62 ± 1.37	12.00 ± 1.50	0.189

Data are presented in Mean±SD or absolute numbers, p value<0.05 is statistically significant. The mean age of patients in Group A was 33.56 ±7.61years and in Group B was 37.00±11.92years. The mean weight of patients in Group A was 54.24±6.317kg and in Group B was 56.04±426kg respectively. When compared statistically using student t-test the difference between the two groups was found to be insignificant (p=0.098).Thus the two groups were comparable with respect to age and weight. The mean duration of laryngoscopy in Group A is 11.62±1.37 seconds whereas in Group B is 12±1.50. When compared statistically using student t-test the difference between the two groups was found to be insignificant (p=0.189).

Table 2: Comparison of HR between Group A and Group B

Heart Rate	Group A	Group B	p value
	Mean ± SD	Mean ± SD	
B1	84.86 ± 11.4	82.96 ± 7.97	0.336
B2	84.92 ± 10.92	82.68 ± 8.06	0.246
B3	81.5 ± 11.21	81.62 ± 9.08	0.953
T0	85.74 ± 10.28	91.26 ± 8.64	0.005
T1	85.58 ± 9.84	95.08 ± 8.02	<0.001
T3	82.48 ± 9.89	90.58 ± 6.63	<0.001
T5	76.56 ± 9.26	83.86 ± 7.13	<0.001
T15	75.22 ± 9.24	84.02 ± 7.86	<0.001

Data are presented in Mean±SD or absolute numbers, * P value<0.05 is statistically significant. It was observed that there was no significant difference in baseline heart rate (B1), heart rate after giving study drug (B2) and post induction heart rate (B3) in both the groups. But heart rate at intubation (T0), 1 min (T1), 3 min (T3), 5 min (T5) and 15 min (T15) after intubation were significantly higher in Group B as compared to Group A. P value = 0.005 at T0 and <0.001 at T1, T3, T5 and T15.

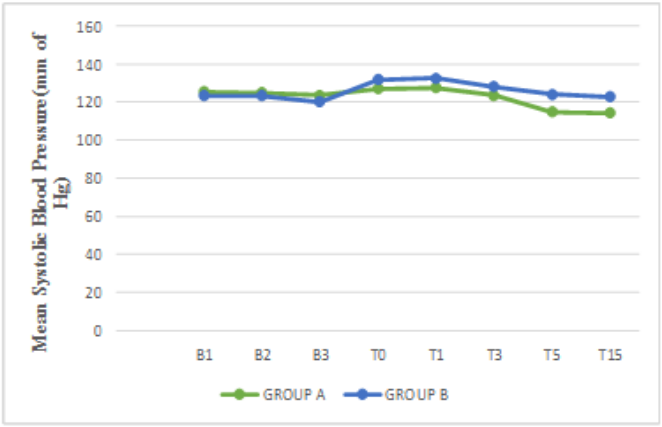

Figure 1: Comparison of SBP between Group A and Group B

During laryngoscopy and intubation (T0) there was a significant difference in SBP between the groups(p value = 0.012). The SBP has increased from the baseline significantly in the Group B as compared to the Group A which attained values below baseline by about the 3rd min postintubation. At the 5th and 15th min, mean SBP was lower with Group A compared to Group B.

Table 3: Comparison of DBP between Group A and Group B

Diastolic Blood Pressure (MM HG)	Group A	Group B	p value
	Mean ± SD	Mean ± SD	
B1	78.82 ± 7.577	77.42 ± 5.729	0.300
B2	78.8 ± 7.134	77.06 ± 5.978	0.189
B3	77.4 ± 6.331	75.68 ± 5.534	0.151
T0	80.32 ± 6.769	84.32 ± 6.079	0.002
T1	81.24 ± 6.394	84.46 ± 5.152	0.007
T3	78.34 ± 6.847	81.12 ± 4.529	0.019
T5	71.02 ± 5.895	79.96 ± 4.651	<0.001
T15	70.36 ± 5.663	79.54 ± 5.589	<0.001

During laryngoscopy and intubation (T0) there was a significant difference in DBP between the group (p value = 0.002). The DBP has increased from the baseline significantly in the Group B as compared to the Group A which attained the baseline values by about the 3rd min postintubation. At the 5th and 15th min, mean DBP was lower with Group A compared to Group B. The increase in DBP was more with Group B at intubation.

Table 4: Comparison of MAP between Group A and Group B

Mean Blood Pressure (MM HG)	Group A	Group B	p value
	Mean ± SD	Mean ± SD	
B1	94.35 ± 7.665	92.75 ± 5.999	0.248
B2	94.14 ± 7.299	92.5 ± 6.017	0.223
B3	92.80 ± 6.599	90.50 ± 5.694	0.065
T0	95.91 ± 6.946	100.15 ± 5.586	0.001
T1	96.71 ± 6.344	100.47 ± 4.534	0.001
T3	93.40 ± 6.616	96.73 ± 4.081	0.003
T5	85.65 ± 5.628	94.67 ± 4.339	<0.001
T15	84.98 ± 5.527	93.91 ± 5.23	<0.001

It was observed that till intubation MAP was statistically comparable in both the groups. But after intubation there was highly significant increase in MAP in Group B as compared to Group A p value <0.05.

Discussion

Laryngoscopy and tracheal intubation bring forth remarkable sympathoadrenal response. In certain groups of patients, such as those who have low myocardial reserve due to coronary artery disease, arterial hypertension, cardiomyopathy, myocardial ischemia and raised intracranial tension such changes may be deleterious. Attenuation of the sympathoadrenal response is important to prevent the adverse events. The accomplishment of smooth induction with least possible reflex hemodynamic response during laryngoscopy and endotracheal intubation remains an anesthetic aim.

Various approaches have been proposed to blunt this unwanted hemodynamic response to laryngoscopy and endotracheal intubation but each method has its own merits and demerits. For example, induction with short acting opioids like fentanyl, alfentanil, sufentanil provide hemodynamic stability during laryngoscopy and intubation but at cost of greater degree of hypotension in immediate preinduction period. Moreover, opioidslead to respiratory depression, chest wall rigidity, impaired psychomotor performance, and increased occurrence of post-operative nausea and vomiting which are not desirable for the patient. Use of halothane for induction precipitates arrhythmias. Calcium channel blockers cause reflex tachycardia, directly acting vasodilators like nitroglycerine need invasive hemodynamic monitoring. Nitroglycerine decreases the hypertensive response to laryngoscopy and endotracheal intubation but not tachycardia. Intubation in a deeper plane also alleviates hemodynamic response. Unfortunately, it can also lead to bradycardia and hypotension due to myocardial depression.

In our study, we used lignocaine (2% preservative free), an amide local anesthetic to blunt the hemodynamic response during laryngoscopy and intubation. Several preparations of lignocaine are available at present. Lignocaine has been used in various modalities such as gargle for anesthetising the oropharynx, intravenous, topical sprays, instillation, or inhalation. [13] Each route has its own merits and demerits. In our study, our primary aim was to compare the effectiveness of intravenous versus nebulised lignocaine for suppression of hemodynamic response to laryngoscopy and intubation. Lignocaine acts by inhibiting the transmission of nerve impulses by blocking the voltage gated sodium channels in cell membrane of nerve cells. Possible mechanisms by which it attenuates the hemodynamic response to laryngoscopy and intubation include direct

myocardial depressant effect, peripheral vasodilatation, and inhibition of synaptic transmission.

In our study we have included patients up to 60 years of age as elderly patients are more often hypertensive and often on certain drugs such as hypnotics, antidepressants and antihypertensives and exhibit varied sensitivity and reactions to drugs. We chose nebulised lignocaine in place of intratracheal lignocaine to reduce the number of laryngoscopic attempts so that there is no confounding. Time taken for laryngoscopy (time in seconds from the time of insertion of the laryngoscope into the mouth to the visual confirmation of intubation) and intubation is comparable in both groups, mean laryngoscopy time in group A is 11.62 and group B is 12 seconds ($p>0.05$). The response to laryngoscopy is dependent on duration of laryngoscopy, which normally peaks in about 45 seconds. More over the amplitude of the hemodynamic response is directly proportional to the duration and force applied during laryngoscopy. Hence we excluded those patients requiring more than one attempt and more than 30 seconds for laryngoscopy. Our data demonstrate that there was an increase in HR and BP from baseline in both the groups with laryngoscopy and intubation. The parameters in the Group A attained the baseline values at the 3rd min postintubation. However, the 5th- and 15th-minute readings showed values below baseline in the nebulization group that is Group A and difference was statistically significant compared to Group B ($p<0.001$).

Jokar et al used 4% nebulised lignocaine and 2% lignocaine for intravenous administration. They found no differences in MAP in control group and intravenous group. They also found significant MAP mean changes over time and average reduction of MAP in inhalation group was faster than intravenous lignocaine and control groups. They concluded that the administration of lignocaine through inhalation leads to a decrease in MAP and pulse rate of the patients even more rapidly than IV injection. [14] Although the results are comparable to our study but in contrast to their study we have used same concentration of lignocaine that is 2% for both nebulization and intravenous route in order to avoid biasing.

Ganesan P et al conducted a study where patients were given either nebulised or IV lidocaine and the HR, saturation, BP, MAP, and arrhythmias were noted every minute from laryngoscopy up to 5 min post laryngoscopy and intubation. They found that there was an increase in HR and BP from baseline in both the groups with laryngoscopy and intubation, and the increase was significantly less in nebulised group ($P < 0.05$). The parameters in both the groups attained the baseline values at the 3rd min postintubation. [15] Where as in our study only the nebulised group attained the baseline values at 3rd min postintubation. However, the 5th-min readings showed values below baseline in the nebulization group which was comparable to our study. Our study revealed similar results to Gupta AN et al who compared attenuation of stress response to laryngoscopy and intubation using nebulised and intravenous lignocaine 2% in dose of 2 mg/kg. [16]

The study conducted by Kocamanoglu IS et al concluded that both intravenously and topically administered lignocaine effectively diminished the hemodynamic responses during intubation. [17] Prasad JR et al concluded that cardiovascular response produced by tracheal suctioning was similar when lignocaine was administered either by intravenous or nebulised form. [10] These studies showed equivalent results in both intravenous and nebulization group on contrary our study has clearly proved nebulised lignocaine superior to intravenous lignocaine.

Bedford et alin their study showed that administration of lignocaine 1.5 mg/kg about 1.5 minutes before intubation produces a mean blood lidocaine level of 3.2 μg/ml before laryngoscopy and intubation which had sufficiently prevented cardiovascular response. [18] We have failed to correlate the attenuation of hemodynamic response with the blood levels of lignocaine in our study.

All patients in our study received 2 mcg per kg fentanyl IV as per our departmental protocol. The use of fentanyl before induction may have had a significant influence in attenuation of pressor response in both the groups. Despite this, the nebulization group had a less pronounced and brief rise in BP, and this suppression, though may not be very useful in normotensive individuals but may be beneficial in hypertensives or patients requiring reduced doses of fentanyl such as the geriatric population.

In our study, nebulised lignocaine was clearly more effective in suppressing the pressor response to laryngoscopy and endotracheal intubation as compared to intravenous lignocaine. We were able to attenuate the pressor response to airway instrumentation by using 2% concentration of nebulised lignocaine which was well tolerated by the subjects.

The limitations of our study was that it was done in normotensive individuals, and the universalization of our results in hypertensive individuals needs further assessment. We did not measure the blood lignocaine levels simultaneously, ideally it would be desirable to correlate the clinical effect of lignocaine with plasma levels at which the clinical effect is achieved. Moreover, patients with anticipated difficult airway need further evaluation.

Nebulisation with lignocaine is an easy, cost-efficient and safe method. It has been used in the field of anaesthesia for suppression of cough and supplementation of airway blocks during awake fibreoptic intubations. Using this technique to attenuate haemodynamic responses to endotracheal intubation is a realistic idea. With the significant increases in haemodynamic parameters observed in the IV lignocaine group compared with nebulisation group, we put forward that nebulisation with lignocaine is a better approach to attenuate haemodynamic responses than IV lignocaine. We believe that with the widespread use of nebulisation of lignocaine, we can replace the use of other pharmacological methods used for the same purpose, thereby avoiding the need to administer multiple drugs and improving cost outcomes.

References

1. King BD, Harris LC, Greifenstein FE, Elder JD, Dripps RD. Reflex circulatory responses to direct laryngoscopy and tracheal intubation performed during general anesthesia. The Journal of the American Society of Anesthesiologists. 1951;12(5):556-66.
2. Prys-Roberts C, Greene LT, Meloche R, Foex P. Studies of anaesthesia in relation to hypertension II: Hemodynamic consequences of induction and endotracheal intubation. Br J Anaesth. 1971; 43:531-47.
3. Fox EJ, Sklar GS, Hill CH, Villauenva R, King BD: Complications related to the pressor response to endotracheal intubation. Anesthesiology. 1977; 47:524-8.
4. Deganwa M., Seth A., Prakash S., Deganwa M., Gogia A. R. Attenuation of the hemodynamic response to laryngoscopy and tracheal intubation with Fentanyl, Lignocaine nebulization, and a combination of both: a randomized controlled trial. Anesth Essays Res. 2016;10(3): 661–6.
5. Pathak D, Slater RM, Ping SS, From RP. Effects of alfentanil and lidocaine on the hemodynamic responses to laryngoscopy and tracheal intubation. J Clin Anesth. 1990; 2:81– 5.
6. Guignard B, Menigaux C, Dupont X, Fletcher D, Chauvin M. The effect of remifentanil on the bispectral index change and hemodynamic responses after orotracheal intubation. Anesth Analg. 2000; 90:161–7.
7. Ward RJ, Allen GD, Deveny LJ, Green HD. Halothane and the cardiovascular response to endotracheal intubation. Anesth & Analg. 1965 Mar 1;44(2):248-52.
8. Talikoti AT, Dinesh K, Deepak VD, Nanda A, Somasekharam P. Comparison ofinjection lignocaine (preservative free) 1.5 mg/kg i.v with oral pregabalin 150 mg for attenuation haemodynamic response to laryngoscopy and tracheal intubation. J Indian Med Assoc. 2013; 111:692-6.
9. Hunt LW, Frigas E, Butterfield JH, Kita H, Blomgren J, Dunnette SL, et. al. Treatmentofasthma with nebulized lidocaine: a randomized, placebo-controlled study. J Allergy Clin Immunol. 2004; 113:853-9.
10. Prasad JR, Reddy KRM, Rao GSU, Radhakrishnana M. nebulised Versus Intravenous Lignocaine to Suppress the Haemodynamic Response to Endotracheal Suction in Patients on Mechanical Ventilation. J Anaesth Clin Pharmacol. 2008;24(4):429-32.
11. Venus B, Polassani V, Pham CG. Effects of aerosolized lidocaine on circulatory responses to laryngoscopy and tracheal intubation. Crit Care Med. 1984; 12:391–4.
12. Wilson IG, Meiklejohn BH, Smith G. Intravenous lignocaine and sympathoadrenal responses to laryngoscopy and intubation. The effect of varying time of injection. Anaesthesia. 1991 Mar;46(3):177-80.
13. Vishalakshi P, Anirudh K, Rathod CV, Sanjivani CR. Comparitive Study Between 2% and 4% Lignocaine Nebulisation on Pressor Response to Laryngoscopy and Intubation. Indian J Public Health Res Develop. 2015;6(2):77-82.
14. Jokar A, Babaei M, Pourmatin S, Taheri M, AlmasiHashiani A, Yazdanbakhsh A. Effects of intravenous and inhaled nebulised lignocaine on the hemodynamic response of endotracheal intubation patients: A randomized clinical trial. Anesth Essays Res. 2018; 12:159-66.
15. Ganesan P, Balachander H, Elakkumanan LB. Evaluation of nebulised lignocaine versus intravenous lignocaine for attenuation of pressor response to laryngoscopy and intubation. Curr Med Issues. 2020; 18:184-8.
16. Amar Nath Gupta, Ravi Anand, Ramanuj Singh. Comparative study of nebulised lignocaine with intravenous lignocaine on stress response to endotracheal intubation. MedPulse International Journal of Anesthesiology November. 2018; 8(2):84-7.
17. Kocamanoglu IS, Cengel Kurnaz S, Tur A. Effects of lignocaine on pressor response to laryngoscopy and endotracheal intubation during general anaesthesia in rigid suspension laryngoscopy. J Laryngol Otol. 2015;129(1):79-85.
18. Bedford RF, Winn HR, Tyson G, Park TS, Jane JA. Lidocaine prevents increased ICP after endotracheal intubation in Intracranial Pressure IV, Shulman K, Marmarou A, Miller JD, Becker DP, Hochwald GM, Brock M, Eds., Springer, Berlin, Germany; 1980; 595.