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Reflex circulatory responses after three stages of nasotracheal intubation and two stages of orotracheal intubation: A comparative study

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ABSTRACT

Background: Endotracheal intubation has become the mainstay of modern anaesthesia. Stimulation of upper respiratory tract during tracheal intubation under general anaesthesia causes activation of sympatho-adrenal system and results in increased serum catecholamines. **Aims and Objectives:** To identify and compare the hemodynamic responses contributed by each stage of nasotracheal with that of orotracheal intubation. **Material and Methods:** About 125 patients in the age group 18-50 years, ASA physical status I-II of either sex, scheduled to undergo various elective surgical procedures requiring nasotracheal or orotracheal intubation were evaluated in the present study.After 4 minutes of ventilation, patients requiring nasal intubation (n = 75) were allocated to three groups- nasopharyngeal intubation group (NPI), nasopharyngeal intubation with laryngoscopy group (NPIL) and nasotracheal intubation group (NTI). Those requiring oral intubation (n = 50) were allocated to two groups namely- laryngoscopy only group (L) and laryngoscopy followed by orotracheal intubation group (OTI). Haemodynamic parameters like heart rate and blood pressure, SpO2, ECG, $ETCO_2$ were monitored continuously and data were recorded before induction, just after induction and after intubation at one minute interval for five minutes. **Results:** The pre-induction and pre-procedure values of systolic, diastolic and mean arterial pressures and also heart rate were similar in each group ($P < 0.05$). Induction of anaesthesia caused a significant decrease in systolic, diastolic and mean arterial pressures in all groups compared to their pre-induction values ($P < 0.0012$). Our study showed that systolic, diastolic and mean arterial pressures were significantly increased after intubation procedures in all the five groups compared to pre-procedure values. **Conclusion:** All the procedures evoked cardiovascular responses characterized by increases in heart rate and blood pressure. NTI produced a significant rise in blood pressure.

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INTRODUCTION

Endotracheal intubation has become the mainstay of modern anaesthesia due to various reasons like maintenance of patency of airway, prevention of pulmonary aspiration, providing positive pressure ventilation, predictable delivery of FiO_2 and elimination of CO_2. Stimulation of upper respiratory tract during tracheal intubation under general anaesthesia causes activation of sympatho-adrenal system and results in increased serum catecholamines.[1] Laryngoscopy[2] and endotracheal intubation[3] are frequently associated with

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significant, though transient, hypertension, tachycardia, arrhythmia and also an increase in intracranial pressure[4]. Although these haemodynamic responses are probably of little consequences in young healthy individuals, they may be more severe and more hazardous in hypertensive and elderly patients which may lead to myocardial ischaemia[5] as well as cerebrovascular accidents[6].

Since King and colleagues first described the reflex circulatory responses to direct laryngoscopy and tracheal intubation in 1951, there have been numerous publications since then concerning both the responses and maneuvers by which it may be attenuated. The majority of studies treated laryngoscopy and intubation as a single stimulus though actually they are not.[4] It has been shown that different phases of intubation[7,8] and passage of endotracheal tube through different parts of airway[9] causes different degrees of cardiovascular responses. Nasotracheal intubation can stimulate the nasal cavity and nasopharynx which does not occur during orotracheal intubation. Previous studies in anaesthetized patients have demonstrated that even simple insertion of a nasopharyngeal airway device can produce significant cardiovascular responses which include rise in systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) along with increase in heart rate.[10] Moreover, there are studies that showed the hypertensive responses to nasotracheal intubation under general anaesthesia are significantly greater[11] and more sustained than that of orotracheal intubation.[12]

However, published studies have provided conflicting evidence. When investigating the pressor responses to tracheal intubation in anaesthetized children, Xue FS, et al.[13,14,15] found no difference between the circulatory responses produced by both conventional and fibreoptic intubation through nasal or oral routes. Consequently, there is evidence that the magnitude of the pressor response varies with the intubation techniques.[16,17,18,19]

In this study, we have divided nasotracheal intubation into three distinct stages namely – nasopharyngeal intubation, direct laryngoscopy, tracheal intubation and orotracheal intubation into two stages – direct laryngoscopy and tracheal intubation with the objective to identify the haemodynamic changes that occur during each stage of intubation through oral and nasal routes. We have used conventional laryngoscope and endotracheal tube wherever applicable.

Aiims and objectives

The study was carried out in a randomized manner to:

1. Observe haemodynamic changes contributed by each stages of intubation through oral and nasal routes.
2. Compare of these results to identify the most noxious stimuli during different stages of endotracheal intubation.

MATERIAL AND METHODS

After approval of the study protocol from the ethical review committee, the work had been carried out in the Department of Anesthesiology, Perioperative Medicine and Pain at Apollo Gleneagles Hospitals, Kolkata. The study included 125 patients of ASA physical status 1 and 2, aged between 18-50years. Informed written consent was obtained from each patient selected for the study after full explanation of the purpose of the study. All these patients underwent elective surgical procedures under general anaesthesia, requiring endotracheal intubation as part of their anaesthetic management.

The exclusion criteria for the study included patients with cardiovascular diseases, morbid obesity, oesophageal reflux disease, bleeding diathesis, diabetes mellitus, history of nasal obstruction and anticipated difficult intubation.

Plan of study

Every patient selected for the study was explained about the procedure and written informed consent was taken. 125 patients thus obtained were allocated according to computer generated randomization table in 5 groups of 25 patients each (n=25).

Patients requiring nasal intubation were allocated to three groups:

a) Nasopharyngeal Intubation Group (NPI)
b) Nasopharyngeal Intubation with Laryngoscopy Group (NPIL) and
c) Nasotracheal Intubation Group (NTI)

Those requiring oral intubation were allocated to two groups namely:

a) Laryngoscopy only Group (L) and
b) Laryngoscopy followed by Orotracheal Intubation Group (OTI)

Preparation of the patient

A day before the scheduled operation the patients were visited preoperatively in their wards for preanaesthetic checkup. After obtaining history, performing clinical examination and reviewing laboratory investigations, the patients were taken up for the study after applying exclusion criteria. All patients had their last oral intake eight hours before the start of anaesthesia and were restricted from oral intake of clear fluid for three hours. All patients received two drops of xylometazoline 0.1% to each nostril 30 minutes prior to arriving in the operating theatre.

Procedure

All patients were monitored with the same calibrated and checked multifunction monitor (Datex Ohmeda F-CU8, Datex Instrumentation, Helsinki, Finland). About 1mg midazolam was given intravenously to all patients 10 minutes before induction of anaesthesia to allay apprehension but maintain co-operation.

All patients were allowed to lie undisturbed for 5 minutes while continuous monitoring of ECG, Heart Rate and Blood Pressure was done and a baseline values of systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MAP) and heart rate (HR) were recorded which was obtained by average of three measurement obtained 2 minutes apart. Then 100% O_2 was administered via a face mask for 3 minutes to achieve denitrogenation.

Anaesthesia was induced using fentanyl citrate 1 mcg/kg followed after 2 minutes by propofol 2.5 mg/kg injected over 15-20 seconds. When loss of response to verbal command occurred, atracurium besylate 0.5 mg/kg was administered intravenously and lungs were ventilated with sevoflurane 1% and nitrous oxide 67% in oxygen via a face mask attached to a circle system. Ventilator settings and fresh gas flow were adjusted to maintain the end-tidal carbon dioxide ($ETCO_2$) at 35-40 mmHg. A Guedel type oropharyngeal airway of appropriate size was used whenever needed to facilitate mask ventilation. Difficulty in mask ventilation was encountered in one patient due to trauma over nasal bridge and the patient was withdrawn from the study and treated appropriately.

After 4 minutes of ventilation, patients requiring nasal intubation (n=75) were allocated to three groups- Nasopharyngeal Intubation Group (NPI), Nasopharyngeal Intubation with Laryngoscopy Group (NPIL) and Nasotracheal Intubation Group (NTI)

Those requiring oral intubation (n=50) were allocated to two groups namely- Laryngoscopy only Group (L) and Laryngoscopy followed by Orotracheal Intubation Group (OTI).

Group allocation was done on a computer generated random number basis. After group allocation, a pre-procedure recording of heart rate, blood pressures, oxygen saturation (SpO_2) and end-tidal carbon dioxide ($ETCO_2$) was taken and the monitor was switched to stand-by mode. All intubation procedures were performed with direct laryngoscopy with Macintosh blade and disposable, cuffed, Portex tracheal tube lubricated with non-anaesthetic jelly by anaesthesiologists experienced in both techniques. In the NPI and NPIL groups, the endotracheal tubes were cut at the level of nostrils to facilitate mask ventilation with the tube in-situ for the study period only after which they were removed and full endotracheal intubation were done. Magill's forceps was used as and when necessary. Laryngoscopy was performed according to the standardized method and external laryngeal compression was used whenever necessary to improve visualization of the glottis.

A third person acted as the time keeper using a digital stopwatch and kept records of the laryngoscopy time and intubation time. Laryngoscopy time was considered as the time interval from insertion to removal of laryngoscopy and intubation time was taken as the time required from introduction of endotracheal tube through mouth or nostril to establishment of ventilation through a facemask in NPI and NPIL groups and through tracheal tube in all other groups.

Following successful intubation and re-establishment of ventilation, five further recordings of heart rate, blood pressures, oxygen saturation (SpO_2) and end-tidal carbon dioxide ($ETCO_2$) were taken at one minute interval for five minutes. During the study period, anaesthesia was maintained through a circle system using sevoflurane 1% with 67% nitrous oxide in oxygen and a fresh gas flow of 3 L/min was used and ventilator settings was adjusted to maintain $ETCO_2$ level of 35-40 mmHg. After recordings were taken, shorten tubes in NPI and NPIL groups were removed and trachea were intubated normally with the aid of a Macintosh laryngoscope and anaesthesia was continued in usual manner.

At the completion of surgery, residual neuromuscular block was antagonized with neostigmine 0.05 mg/kg and glycopyrrolate (0.01 mg/kg) intravenously and the trachea was extubated when the patient was awake. Postoperative pain relief was provided with pethidine 1.5 mg/kg intramuscularly 8 hourly or when pain score was ≥5 (VAS). All patients received moist oxygen supplementation (4l/min) for 2 hours and were continuously monitored.

Statistical analysis

Continuous variable such as demographic data was analyzed with the one-way analysis of variance (ANOVA) and student's t test. Two-way ANOVA was used for multiple comparisons served to compare MAP and HR data between groups. Within each group, we compared MAP and HR values at one-minute intervals after intubation with the values observed just before intubation, using Friedman's repeated measures ANOVA with multiple comparisons versus control using Dunnett's test. Discrete variables were compared by chi-square test (X^2) and Kruskal-Wallis test as appropriate. Power analysis before the study showed

that to detect a difference in mean arterial pressure of 12 mm Hg, a sample size of 25 patients would be required in each group to have a 95% chance with an alpha error of 0.05 and beta of 0.2. P < 0.05 was considered statistically significant. All the data were analyzed using the software InStat, version 3.00.

RESULTS

All the five groups were comparable with regard to age, weight and sex distribution (Table 1). There was no statistically significant difference among the groups (P>0.3045).

The mean time to complete nasotracheal intubation was 34 seconds which was significantly greater than that required to complete orotracheal intubation which was 22.8 seconds (P<0.001) (Table 2).

The pre-induction and pre-procedure values of systolic, diastolic and mean arterial pressures and also heart rate were similar in each group (P<0.05) (Table 3). Induction of anaesthesia caused a significant decrease in systolic, diastolic and mean arterial pressures in all groups compared to their pre-induction values (P<0.0012). The mean heart rate was also increased significantly after induction of anaesthesia in each of the five groups (P<0.001).

Our study showed that systolic, diastolic and mean arterial pressures were significantly increased after intubation procedures in all the five groups compared to pre-procedure values (Table 4). However, the increases in the arterial pressures in the orotracheal (OTI) and nasotracheal intubation groups (NTI) were significantly greater than that in other groups. Moreover, the hypertensive response in nasotracheal intubation group (NTI) was significantly greater (Figure 1) and more sustained than that of orotracheal intubation group (OTI) [MAP 159(4) mm Hg vs. 124(3) mm Hg at 2 min. (P<0.001)]. Systolic, diastolic and mean pressures remained significantly elevated for 2 minutes in the orotracheal intubation group (OTI) [MAP 124(3) mm Hg vs. 82(4) mm Hg] and for 4 minutes in nasotracheal intubation group (NTI) [MAP 107(3) mm Hg vs. 85(6) mm Hg] in comparison to their pre-procedure values. Again, increase in the arterial pressures in nasopharyngeal intubation group (NPI) and nasopharyngeal intubation plus laryngoscopy group (NPIL) were significantly greater than direct laryngoscopy only group (L) (P<0.001). However, there was no significant difference in the pressure changes between NPI group and NPIL group (P>0.05).

After the procedure (laryngoscopy or intubation or both) has been carried out, the heart rate in the NPI and NPIL groups decreased and at 4 minutes post-procedure, the heart rate was significantly lower than pre-procedure heart rate in these two groups (P<0.0001) (Table 5). There was no significant difference in changed heart rates between the NPI and NPIL group (P>0.05). However, laryngoscopy alone caused a small statistically non-significant increase in mean heart rate (P>0.99). The heart rate increased significantly after nasotracheal and orotracheal intubations and at 2 minutes after the procedure, increases in heart rate were significantly greater than pre-induction level and in comparison to other three groups (P<0.001). Tachycardia was sustained for 3 minutes in each group and then gradually decreased. However, the tachycardia associated with nasotracheal intubation in NTI group was significantly less than that of orotracheal intubation in OTI group during the 1st minute after intubation [100(10) beats/min vs. 130(10) beats/min (P<0.001)] after which they were similar. The comparative changes in heart rate in each group after every min for five min after the procedure were shown in Figure 2.

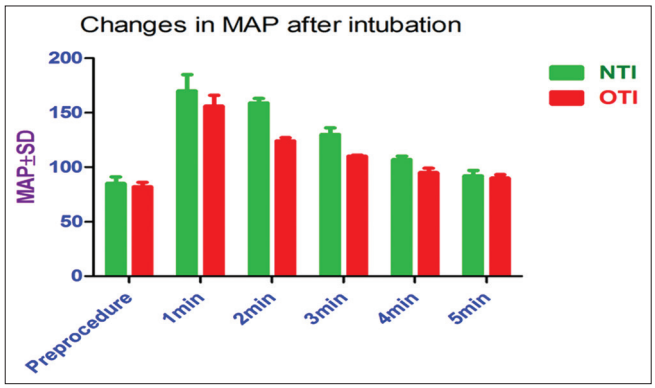

Figure 1: Mean arterial pressure (mmHg) changes in NTI VS. OTI

Table 1: Demographic data of patients (Mean values±SD)

Groups	NPI	NPIL	NTI	L	OTI
Age	27.9 (18-44)	27.1 (19-43)	30.8 (20-50)	29.5 (18-46)	30.9 (22-50)
Weight	46.55 (36-55)	47.37 (35-62)	46.5 (35-50)	47.5 (35-60)	46.7 (37-58)
Sex	15M, 10 F	14M, 11F	9M, 16F	13M, 12 F	12M, 13F

DISCUSSION

The aim of anaesthesiologist is not only to ensure a smooth induction and intubation but also to ensure an uneventful postoperative period. The challenge in anesthesia is to maintain a balance between the stress of the laryngoscopy, tracheal intubation, and surgical procedure with the cardiorespiratory depressant effects of deeper levels of anesthesia. Laryngoscopy and tracheal intubation is a strong stimulus for cardiovascular system under light anesthesia. Cardiovascular responses such as tachycardia and hypertension occur during laryngoscopy and intubation, though transient may produce deleterious effects particularly in elderly patients and those with coronary and cerebrovascular diseases.

Nasotracheal intubation (NTI) is one of the commonest methods used to induce anaesthesia for surgeries of the head and neck region. NTI involves the tracheal tube to pass through nose hence allowing better isolation and good surgical access for intraoral procedures.

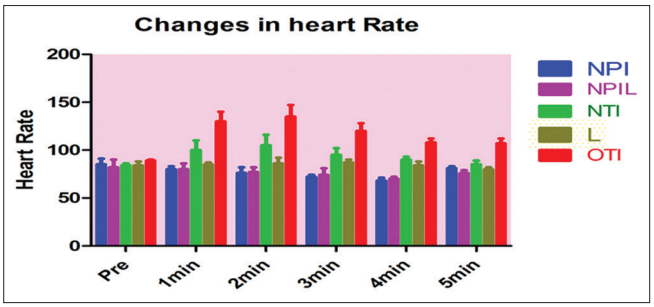

Figure 2: Heart rate changes (beats/min) in each group after intubation compared to pre-procedure values

Table 2: Intubation time (Mean±SD)

Groups	NPI	NPIL	NTI	L	OTI
Mean time (sec)	8 (2)	16 (6.8)	34 (1.8)	15	22.8 (1.1)
Range (sec)	6-11	10-20	20-53	12-15	8-34

It is well known that stimuli to airway structures are the main causes of the circulatory responses to tracheal intubation.[20] It has been shown that there are significant differences in circulatory responses to airway stimulation at different sites.[9] The circulatory responses during tracheal intubation also varies with depth of anaesthesia[21], duration of the procedure[22] and the difficulties encountered during laryngoscopy and intubation[23] as well as patient dependent variables including age[24] and co-existing medical illness[24,25].

The haemodynamic responses during laryngoscopy depend on the forces applied during the procedure causing mechanical stimulation of the airway.[23] When laryngoscopy is difficult, the force applied to get a clear view of glottis is increased, leading to an increased pressor response. Limiting the duration of laryngoscopy and the forces required during this is an effective means of preventing the exaggerated haemodynamic responses.

Increased intubation time may also contribute more severe pressor responses. Stoelting[22] demonstrated that increasing the duration of Macintosh laryngoscopy caused exaggerated pressor responses during nasotracheal intubation that may lead to a serious hazard in patients subjected to cardiovascular instability. The exaggerated haemodynamic responses during tracheal intubation in hypertensive patient are due to arteriolar luminal narrowing, blunted baroreceptor reflex and sympathetic over-activity.[25]

The increased cardiovascular responses to direct laryngoscopy and tracheal intubation in diabetic patients reflect autonomic neuropathy. The increased stress response in these patients may be caused by autonomic dysfunction due to denervation hypersensitivity of the sympathetic receptors.[24]

Many studies have compared the cardiovascular responses with design of laryngoscope blade.[26,27] They concluded that Macintosh blade compressed the soft tissue of anterior epipharynx more, producing increase in heart rate and blood pressure when compared to straight blade

Table 3: Baseline and post-induction systolic (SAP), mean (MAP) and diastolic (DAP) arterial pressure (mm Hg) and heart rate (beats/min) (data expressed as Mean±SD)

Groups	NPI	NPIL	NTI	L	OTI
Preinduction values					
SAP	116 (6)	113 (4)	110 (6)	111 (3)	112 (4)
MAP	91 (2)	90 (2)	90 (4)	91 (1)	91 (2)
DAP	66 (8)	68 (3)	70 (8)	70 (2)	73 (7)
HR	80 (4)	75 (2)	74 (3)	72 (6)	82 (2)
Pre-procedure values					
SAP	106 (6)	108 (8)	100 (10)	112 (4)	105 (10)
MAP	80 (4)	82 (5)	85 (6)	84 (2)	82 (4)
DAP	54 (10)	57 (8)	58 (6)	60 (5)	57 (6)
HR	85 (6)	82 (8)	84 (2)	84 (4)	89 (1)

Table 4: After procedure systolic (SAP), mean (MAP) and diastolic (DAP) arterial pressure (mm Hg) (data expressed as Mean±SD)

Groups	NPI	NPIL	NTI	L	OTI
1 min					
SAP	124 (15)	125 (9)	170 (15)	122 (8)	156 (10)
MAP	106 (8)	110 (6)	135 (8)	98 (4)	131 (6)
DAP	82 (5)	85 (6)	100 (10)	82 (5)	107 (4)
2 min					
SAP	136 (12)	142 (10)	210 (5)	134 (10)	168 (8)
MAP	112 (8)	116 (5)	159 (4)	103 (7)	124 (3)
DAP	82 (8)	90 (3)	108 (4)	89 (6)	95 (2)
3 min					
SAP	136 (3)	140 (2)	160 (8)	120 (5)	146 (5)
MAP	106 (2)	108 (5)	130 (6)	98 (1)	110 (1)
DAP	76 (1)	82 (3)	100 (5)	76 (2)	84 (2)
4 min					
SAP	122 (7)	128 (5)	140 (6)	116 (6)	117 (6)
MAP	91 (6)	95 (3)	107 (3)	93 (2)	95 (4)
DAP	70 (8)	74 (2)	74 (5)	78 (2)	73 (3)
5 min					
SAP	110 (4)	116 (4)	115 (5)	112 (4)	109 (6)
MAP	84 (2)	86 (2)	92 (5)	91 (3)	90 (3)
DAP	74 (1)	76 (1)	80 (4)	70 (2)	78 (4)

Table 5: After procedure heart rate (BEATS/MIN) changes (data expressed as Mean±SD)

Time after the procedure	NPI	NPIL	NTI	L	OTI
1 min	80 (3)	80 (6)	100 (10)	85 (2)	130 (10)
2 min	76 (6)	77 (5)	105 (11)	86 (6)	135 (12)
3 min	72 (2)	74 (7)	95 (7)	87 (3)	120 (8)
4 min	68 (3)	70 (2)	90 (3)	84 (4)	108 (4)
5 min	81 (2)	76 (3)	85 (4)	80 (2)	107 (5)

laryngoscope. Laryngoscopy with McCoy blade produces minimal haemodynamic changes with the absence of any significant change in plasma noradrenalin concentration.

Previous work has suggested that simple nasopharyngeal intubation and insertion of a nasopharyngeal airway produces a significant hypertensive response.[8,10] Also the increase in blood pressure after laryngoscopic nasotracheal intubation is significantly greater than that after laryngoscopic orotracheal intubation under the comparable conditions.[11,12]

Our study showed a significant hypertensive response following nasopharyngeal stage of intubation (introducing endotracheal tube up to nasopharynx) (P<0.001). Applying direct laryngoscopy for clinically appropriate time immediately after passing the tracheal tube into thenasopharynx did not add significantly to this response. Advancing the tube from nasopharynx into the larynx and the trachea added substantially to the hypertensive response generated by the first two stages of nasotracheal intubation. These changes were observed even after administration of fentanyl citrate, a drug known to reduce the pressor response.[28]

The study also showed that hypertensive response to nasotracheal intubation was significantly greater and more sustained when compared to orotracheal intubation (P<0.001). This is similar with the previous observation done by Smith JE et al.[12] It seems likely that the nasotracheal intubation produces a greater mechanical stimulation of the upper airway and that this generates a more vigorous activation of sympathetic nervous system. Increased intubation time may also contribute to the more severe pressor response.

The mean heart rate was increased significantly after induction of anaesthesia in each of the five groups (P<0.0012). But after the procedure (laryngoscopy or intubation or both) has been carried out, the heart rate in the NPI and NPIL groups decreased and at 4 minutes post-procedure, the heart rate was significantly lower than pre-induction heart rate in these two groups (P<0.0001).

There was no significant difference in postprocedure heart rate between the NPI and NPIL group (P>0.05). However, laryngoscopy alone caused a small statistically non-significant increase in mean heart rate (P<0.99). The heart rate increased significantly after nasotracheal and orotracheal intubations. But the heart rate was decreased as in the nasopharyngeal intubation plus laryngoscopy group.

CONCLUSION

The present study was carried out to observe haemodynamic changes contributed by each stage of intubation through oral and nasal routes and comparison of these results to identify the most noxious stimuli during different stages of endotracheal intubation.

All the procedures evoked cardiovascular responses characterized by increases in heart rate and blood pressure. Nasopharyngeal intubation produced a significant rise in blood pressure. Increase in the arterial pressures in nasopharyngeal intubation group (NPI) and nasopharyngeal intubation plus laryngoscopy group (NPIL) were significantly greater than direct laryngoscopy only group (L). These exaggerated hypertensive responses may lead to life threatening condition in patients with cardiac co-morbidities.

The decision of nasotracheal intubation should be carefully reviewed and if nasotracheal intubation is considered advantageous, effective measures should be implemented to minimize the cardiovascular responses.

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