Original Article

Deliberate Controlled Hypotension in Functional Endoscopic Sinus Surgeries: A Comparative Study between Nitroglycerin and Esmolol

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Abstract

Background: Functional endoscopic sinus surgery (FESS) enjoys the privilege of being a minimally invasive intervention for nasal disorders. Intraoperative bleeding is the major problem in these endoscopic surgeries. Excessive bleeding impairs operative visibility, prolongs the duration of surgery and anesthesia, and increases the risk of complications. Controlled hypotension is a method wherein the arterial blood pressure is lowered in a deliberate but predictable manner to reduce the intraoperative bleeding and enhance the surgical field visibility. **Aim:** The aim of this study was to compare the mean change in heart rate (HR), systolic blood pressure, diastolic blood pressure, mean arterial pressure (MAP), surgical bleeding, and duration of hypotensive anesthesia caused by nitroglycerin (NTG) or esmolol (ESM), when performing FESS. **Materials and Methods:** Sixty patients of American Society of Anesthesiologists I and II undergoing FESS under general anesthesia were divided into two groups– the NTG and the ESM group. Vitals were recorded at regular intervals. Hemorrhage was estimated by volumetric and gravimetric estimation. Visibility of the surgical field was rated by the surgeon Fromme *et al*, with 0 being the driest and 5 making surgery impossible. **Results:** Intraoperative HR, surgical bleeding, and duration were less in the ESM group. Visibility was much superior in this group too. **Conclusions:** Both drugs are safe and effective in providing optimal operating conditions, but ESM is superior because it provides superior surgical dryness at higher MAPs and reduces the surgical blood loss and duration more than NTG. Absence of reflex tachycardia was the added advantage of ESM over NTG.

Key words: Average category scale (Fromme), esmolol, functional endoscopic sinus surgery, heart rate, mean arterial blood pressure, nitroglycerin

Introduction

Bleeding is a major operative problem in surgeries, especially of the paranasal sinuses, middle ear cavity, and the spine. It is pertinent to minimize this bleeding electively than subject the patient to the risks associated with blood transfusion. Controlled hypotension is a technique wherein the arterial blood pressure is lowered in a deliberate but controllable manner to minimize surgical blood loss and enhance the operative field visibility to reduce the overall duration of surgery and anesthesia.[1]

There are several pharmacological and nonpharmacological techniques of inducing hypotension, the mechanical ones being tourniquets, table positioning, and intermittent positive pressure ventilation.[2,3]

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Alpha receptor agonists and antagonists such as dexmedetomidine and phentolamine, respectively, beta receptor antagonists such as esmolol (ESM), nitrovasodilators such as sodium nitroprusside and nitroglycerin (NTG), opioids such as remifentanil and anesthetic agents such as propofol, halothane, and isoflurane have all been used successfully for controlled hypotensive anesthesia.[4-12]

This study attempted to compare the hypotensive efficacies of the nitrovasodilator NTG and the β-blocker ESM.

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Materials and Methods

This study was conducted in the Department of Anaesthesiology, Adichunchanagiri Institute of Medical Sciences, after obtaining approval by the Institutional Ethics Committee.

Sixty patients aged between 18 and 60 years of either sex, scheduled for an elective Functional endoscopic sinus surgery (FESS) belonging to American Society of Anesthesiologists Status I and II, were included in this study. Written informed consent was taken from all the patients. Patients with anaemia, diabetes, hypertension, and cardiovascular or cerebrovascular diseases were excluded from this study.

All patients received tablet ranitidine 150 mg before and tablet alprazolam 0.5 mg after their evening meals after which, all patients were kept nil orally for a minimum of 8 h before the scheduled time of surgery. Two intravenous (IV) accesses were secured on either hand – one meant for the hydrating fluids and the other for the hypotensive drug. All patients were catheterized for monitoring the urine output. These patients were then connected to the multichannel monitor which continuously recorded their heart rates (HRs) and rhythm, noninvasive blood pressure (systolic blood pressure [SBP], diastolic blood pressure [DBP], and mean arterial pressure [MAP]), end-tidal CO_2, and oxygen saturation.

Anesthesia was induced with IV therapy thiopentone and laryngoscopy and intubation facilitated with IV vecuronium. Care was taken to ensure a smooth, dextrous, and gentle laryngoscopy so as to avoid any hemodynamic variations from the basal values.

Anesthesia was maintained with 0.4% isoflurane in balanced N_2O/O_2 mixture and vecuronium boluses at appropriate intervals. The dial concentration of isoflurane was kept constant throughout the anesthetic duration.

Now, the NTG group (n = 30) received IV infusion of NTG (5–10 mcg/kg/min) and ESM group (n = 30) received IV infusion of ESM 100–300 mcg/kg/min after a bolus of 500 mcg/kg over 30 s through syringe pumps.

The MAP was gradually reduced in decrements of 5 mmHg. The infusions were finely adjusted and steadied when the MAP reached 60–65 mmHg or when the surgeon gave 2 points for the operative visibility on the average category scale (ACS) of Fromme *et al*.,[13] whichever was earlier.

Surgery was allowed to commence at the 5th min of infusion. All patients received a local infiltration of lignocaine in adrenaline by the surgeons before commencement of the surgery.

Patients who developed severe hypotension (MAP <60 mmHg) were first observed for 5 min after discontinuation of the hypotensive agent and if the MAP persisted or did not improve, they were promptly treated with a 6 mg bolus of injection ephedrine. These patients were excluded from the study. Similarly, any patients in the ESM group who might develop bradycardia (<50) were supposed to receive injection Atropine can be excluded from this study in the event of such an occurrence if at all.

Continuous audio-visual monitoring was carried out throughout the procedure for HR, cardiac rhythm, SBP, DBP, MAP, pulse oxymetry, capnometry, and urine output.

Neuromuscular monitoring was conducted with the Train-of-Four sequence.

Infusion of the hypotensive agent was stopped 10 min before the anticipated end of surgery. Isoflurane was stopped 5 min before the end of the surgery. The balanced N_2O/O_2 mixture was gradually converted to 100% O_2 to avoid diffusion hypoxia.

The operative field was judged by the same operating surgeon who was blinded to the induced hypotensive agent used using Fromme's scale[13] as follows:

- 5: Massive uncontrollable bleeding. Surgery impossible. Constant suctioning required
- 4: Heavy but controllable bleeding that interferes with dissection. Prompt suctioning required
- 3: Moderate bleeding that moderately compromises surgical dissection. Frequent suctioning required
- 2: Moderate bleeding but without interference with accurate dissection. Surgical field not threatened. Occasional suctioning required
- 1: Bleeding, so mild, it is not even a surgical nuisance. No suctioning
- 0: No bleeding, virtually bloodless field.

Results

Sixty patients undergoing FESS under general anesthesia who received either NTG (n = 30) or ESM (n = 30) for deliberate hypotension were studied and the following observations were made.

There was no statistically significant difference in the demographic characteristics of the patients in the two groups [Table 1].

In the NTG group, the basal HR was in the range of 85.83 ± 9.46 beats per minute and in the ESM group, it was 82 ± 10.47 beats per minute. This difference was comparable, but was statistically insignificant.

At the 10th min of infusion, however the HRs in group ESM were much lower (74.90 ± 5.26 bpm) compared to the NTG group (96.03 ± 8.21 bpm). This difference is highly

Table 1: Demographic characteristics of the patients

Characteristics	NTG group (n=30)	ESM group (n=30)	P
Mean age (years)	36.17	37.10	NS
Gender distribution male: female	15:15	20:10	NS
Mean weight (kg)	60.93	62.47	NS

NTG: Nitroglycerin, ESM: Esmolol, NS: Not significant

significant ($P < 0.01$). The ESM group displayed a lower mean HR (−15.02%) and the NTG group had a slight rise (+2.78%) in the mean HR from the basal HR during the hypotensive period as shown in Graph 1 and Table 2.

The mean basal values of SBP of the NTG group were 127.20 ± 5.73 whereas that of ESM were 124.50 ± 7.64 [Table 3]. These values are comparable, but statistically insignificant. It is noteworthy that on an average, the NTG group achieved a fall in SBP much earlier than in the ESM group (at 10th min, NTG = 104.97 ± 3.60 and ESM = 115.27 ± 5.78). This difference is highly significant ($P < 0.01$) [Graph 2 and Table 2].

The mean basal DB*P* values of NTG and ESM group were 77.23 ± 6.06 and 79.20 ± 5.29, respectively. The percentage of reduction of DBP from baseline values in the hypotensive period was 22.41% in the NTG group and 15.25% in the ESM group. Throughout the hypotensive period, the difference in DBP between the two groups was highly significant [Graph 3 and Table 4].

The basal MA*P* values of NTG and ESM group were 93.53 ± 5.26 mmHg and 92.87 ± 4.42 mmHg, respectively.

Table 2: Mean change in the heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure during the hypotensive period, mean average category scale, mean surgical blood loss, and mean duration of surgery

Parameter	NTG group	ESM group	*P*
Mean percentage change in HR in the hypotensive period	+2.78	−15.02	<0.01
Mean percentage of reduction in SBP in the hypotensive period	29.25	20.76	<0.01
Mean percentage of reduction in DBP in the hypotensive period	22.41	15.25	<0.01
Mean percentage of reduction in MAP in the hypotensive period	24.28	16.80	<0.01
Mean average category scale (Fromme)	2.42±0.77	1.95±0.73	<0.01
Mean surgical blood loss (ml)	191.7±25.3	179.5±16.8	<0.05
Mean duration of surgery (min)	110.8±9.6	98±9.2	<0.01

NTG: Nitroglycerin, ESM: Esmolol, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MPA: Mean arterial pressure

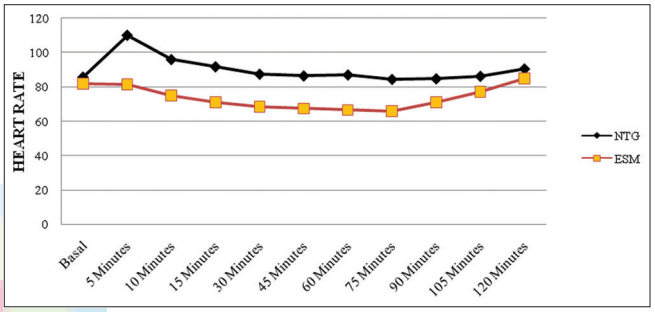
Table 3: Basal and intraoperative mean arterial pressure (mmHg) during the procedure

Time (min)	Group NTG (*n* = 30)	Group ESM (*n* = 30)	*P*
Basal	93.53±5.26	92.87±4.42	NS
5	103.37±6.23	96.33±3.88	<0.01
10	95.20±5.66	87.12±3.35	<0.01
15	74.16±3.20	79.25±3.69	<0.01
30	67.71±3.42	74.81±1.23	<0.01
45	64.42±2.25	71.79±13.10	<0.01
60	64.41±1.59	74.95±1.33	<0.01
75	64.97±1.91	75.35±1.29	<0.01
90	66.39±1.53	76.66±1.42	<0.01
105	68.63±1.57	78.27±1.12	<0.01
120	70.84±1.16	80.50±2.55	-

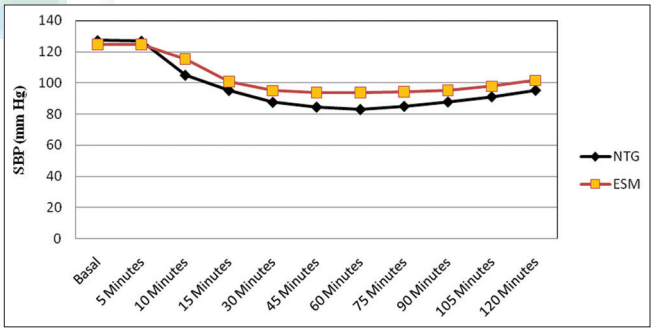
NTG: Nitroglycerin, ESM: Esmolol, NS: Not significant

This difference is comparable, but clinically insignificant. On an average, the mean of the MAPs of ESM group in the hypotensive period was 77.26 ± 7.26 mmHg whereas for NTG, it was 70.82 ± 10.15 mmHg. This is a 16.80% and 24.28% reduction from baseline values [Table 3]. The target MAP, however, was achieved earlier in the NTG group [Graph 4 and Table 3].

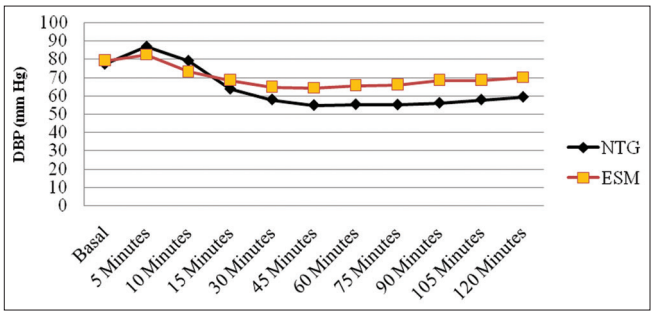
The patients of the ESM group achieved the target Fromme's score of 2 earlier than the NTG group [Table 4]. The surgical dryness was maintained in the ESM group at higher MAP (65-70 mmHg) than in the NTG group (60–65 mmHg). None of the patients of the NTG group and a few in the ESM group had a score of 0. At 30 min of infusion, all the patients of the ESM group had a surgical score of 2 while 22 patients in the NTG group had the same. The average surgical durations of the NTG group and ESM group were 110.8 ± 9.6 min and 98 ± 9.2 min, respectively. The average blood losses between



Graph 1: Mean change in the heart rate (bpm) of the patients at various intervals during the hypotensive period



Graph 2: Comparison of systolic blood pressure (mmHg) between the two groups



Graph 3: Comparison of diastolic blood pressure (mmHg) between the two groups

the NTG group and ESM group were 191.7 ± 25.3 ml and 179.5 ± 16.8 ml ($P < 0.05$), respectively.

None of the patients of either group had any complications such as bradycardia, reflex tachycardia, and rebound hypertension. None of them required any hemotransfusion, whatsoever.

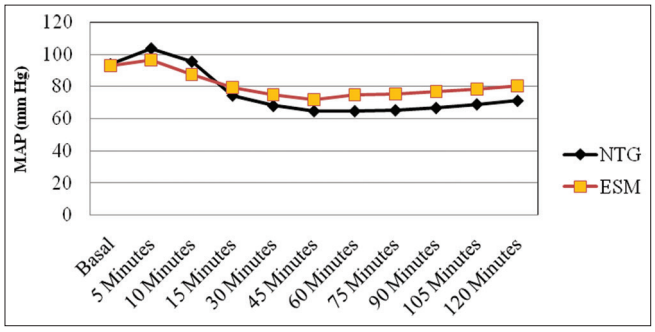
Discussion

Nitrovasodilators such as NTG dilate the capacitance vessels and reduce the venous return with concomitant reductions in stroke volume and cardiac output, thereby causing hypotension.[14] ESM produces hypotension by reducing the HR, cardiac output, and blood pressure.[15]

This fall in HRs in the ESM group is attributed to the beta-adrenergic blocking effects of ESM. Throughout the surgery, the mean HRs in the ESM group were much lower than in the NTG group. The mean HRs in the NTG group are consistent with the fact that NTG causes either no change or a slight increase in HRs during a continuous infusion as a reflexive phenomenon which is the baroreceptor-mediated response secondary to the hypotension. Compared to the baseline values, there was a 15.02% fall in HR in the ESM group in the hypotensive period whereas in the NTG group, it was a 2.78% increase. None of the patients in the ESM group suffered from clinically significant bradycardia (<50/min).

This is purely attributed to the mechanism of hypotension caused by each drug. NTG has a venodilatory action whereas ESM reduces the cardiac output by negative chronotropism. The latter mechanism takes some time. The average reduction in SBP from basal values in the hypotensive period was 29.25% for NTG and 18.13% for ESM group. Even though the SBP reduction was higher in the NTG group, the surgical dryness was superior in the ESM group. On examining the mean MAPs of both groups, we found that the ESM group achieved the target SFR of 2 or below at higher MA*P* values and hence, the MAPs were not further lowered in this group. To achieve similar operative dryness, the MAP had to be reduced much lower in the NTG group.

In this study, we achieved favourable operative conditions with a MAP of 74.81 ± 1.23 versus 67.71 ± 3.42 (30 min), 71.79 ± 13.10 versus 64.42 ± 2.25 (45 min), 74.95 ± 1.33 versus 64.41 ± 1.59 (60 min), 75.35 ± 1.29 versus 64.97 ± 1.91 (75 min), 76.66 ± 1.42 versus 66.39 ± 1.53 (90 min), and so on. On an average, we found that similar operative visibility was obtained in the ESM group with much higher MAPs than in the NTG group.



Graph 4: Comparison of mean arterial pressure (mmHg) between the two groups

The Fromme *et al*.[13] scoring system was accepted to enable the surgeon to make his/her own assessment of the operative field. This ACS consists of 6 points (0–5) with 0 being the driest and 5 making surgery impossible. In this visual scale, the surgeon opines on the quality of the surgical field and gives scores. This scoring system has been used by almost all authors who have attempted to study hypotensive anesthesia.

The Fromme's score at 10th min was 4 in 19 patients in the NTG group whereas 18 patients in the ESM group had a score of 3. At 30 min, all the thirty patients of the ESM group had a score of 2, while 22 patients had the same score in the NTG group. It is also worthwhile to reiterate the point that at 30 min, the MAP in the ESM group was 74.81 ± 1.23 versus 67.71 ± 3.42 in the NTG group. From 45 min onward, most patients in both groups either had a score of 2 or 1 (MAPs were adjusted and stabilized accordingly). In the ESM group, we found that more patients had a score of 1 than in the NTG group. Only 4 patients in the ESM group ever had a score of 0 (75 min onward) and none in the NTG group displayed similarity. The best score in the NTG group was 1 and the worst was 5. For the ESM group, it was 0 and 4, respectively. When we compared the mean differences in the category scales, we found that the mean score for NTG was 1.96 ± 0.20 and 1.50 ± 0.86 for ESM. This difference is highly significant ($P < 0.01$). At 15 min, the surgical field in the ESM group is superior by 1 point (2 vs. 3).

Capillary bleeding is the major impediment in FESS. ESM blocks the adrenergic effect of vasoactive amines released during hypotension. During ESM-induced hypotension, unopposed alpha-adrenergic effects cause vasoconstriction of arterioles and precapillary sphincters leading to the nasal mucosal blood vessels to contract and cause less oozing and thus, providing for a superior operative field via its HR control-related bleeding and surgical-site quality in FESS.

Table 4: Fromme score comparison during hypotensive anesthesia periods between the two groups

Time (min)	NTG group score ($n=30$)						ESM group score ($n=30$)					
	0	1	2	3	4	5	0	1	2	3	4	5
10	0	0	0	7	19	4	0	0	8	18	4	0
15	0	0	1	21	8	0	0	0	18	12	0	0
30	0	0	22	8	0	0	0	0	30	0	0	0
45	0	1	24	5	0	0	0	8	22	0	0	0
60	0	1	27	2	0	0	0	8	22	0	0	0
75	0	1	29	0	0	0	4	4	22	0	0	0
90	0	1	29	0	0	0	7	1	22	0	0	0
105	0	1	25	0	0	0	1	0	6	0	0	0
120	0	0	9	0	0	0	1	0	1	0	0	0

NTG: Nitroglycerin, ESM: Esmolol

Endogenous catecholamine has a negligible effect on vascular smooth muscles when NTG is used. This results in vasodilatation with the consequence of more oozing and surgical blood loss.[5] In addition, reflex tachycardia will further contribute to this. These factors contribute to more oozing and a longer duration of surgical intervention.

Conclusions

Both drugs are safe and effective in providing optimal operating conditions but esmolol is superior because it provides superior surgical dryness at higher MAPs and reduces the surgical blood loss and duration more than nitroglycerin. Absence of reflex tachycardia was the added advantage of esmolol over NTG.

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Conflicts of interest

There are no conflicts of interest.

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