Controlled Hypotension for Functional Endoscopic Sinus Surgery: Comparison of Esmolol and Nitroglycerine

U. Srivastava · A. B. Dupargude · D. Kumar ·
K. Joshi · A. Gupta

Received: 14 July 2012 / Accepted: 15 April 2013 / Published online: 27 April 2013
© Association of Otolaryngologists of India 2013

Abstract Intraoperative bleeding causing poor visibility of surgical field is of major concern during functional endoscopic sinus surgery (FESS) and impaired visibility may result in many complications. The study aimed to compare surgical conditions for FESS during controlled hypotension provided by esmolol or nitroglycerine (NTG) under general anaesthesia. 52 adult patients of both sexes requiring FESS under general anaesthesia were randomly divided to receive either esmolol (group ESM, $n = 26$) or NTG (group NTG, $n = 26$) to provide controlled hypotension. Surgical condition was assessed by surgeon using average category scale (ACS) of 0–5, a value of 2–3 being ideal. In both groups mean arterial blood pressure (MABP) was gradually reduced till ACS for assessment of surgical condition (ACS) of 2–3 or lowest targeted MABP (60 mm of Hg) was achieved. Both the drugs produced desired hypotension and improved surgical condition by reducing operative field bleeding but ideal operative conditions were achieved at mild hypotension (MABP 75–70) in ESM group while same conditions were achieved at MABP of 69–65 mm of Hg in NTG group. Mean heart rate was significantly higher in NTG group as compared to ESM group. Blood loss was significantly less in ESM group. Both NTG and esmolol can be used safely to provide controlled hypotension during FESS. Both the drugs improved visibility of surgical field by reducing capillary

bleeding. But esmolol offered better operative conditions with only minimal reduction in MABP. No reflex tachycardia and less intraoperative haemorrhage were additional advantages of esmolol.

Keywords FESS · Controlled hypotension · Esmolol · Nitroglycerine

Introduction

Functional endoscopic sinus surgery (FESS) is most exciting recent surgical development for treatment of patients with nasal and paranasal sinus pathology. The term FESS is used to draw attention to the potential for re-establishing natural mucociliary clearance mechanism, drainage and aeration of sinuses, whilst maintaining as much of the normal anatomy as possible [1–3]. Over last few years this technique has become popular worldwide due to its minimally invasive nature and preservation of mucosa. Bleeding is one of the major problems during surgery which reduces operative field visibility [4]. This may not only prolong the surgical duration but also increase the chances of complications [3]. Epinephrine injection in the nasal mucosa, patients head elevation and controlled hypotension can be used to minimize bleeding, improve surgical field and prevent complications [4–6]. This can be done by using hypotensive drugs such as B blockers, calcium channel blockers, vasodilators, or by anaesthetic drugs like propofol, opioids and inhalational agents [4–9]. This study was designed to provide controlled hypotension using nitroglycerine (NTG) or esmolol in patients undergoing in FESS under general anaesthesia. The primary aim of this study was to compares quality of surgical field. We also determined if the technique had any

U. Srivastava (✉) · A. B. Dupargude · K. Joshi · A. Gupta
Department of Anaesthesia & Critical Care, SN Medical College
& Hospital, Agra, India
e-mail: drumasrivastava@rediffmail.com

D. Kumar
Department of ENT, SN Medical College & Hospital,
Agra, India

impact on blood loss and adverse events during peri-operative period.

Materials and Methods

After acquiring Institutional Review Board approval this prospective randomized study was conducted on fifty-two healthy patients who underwent elective FESS under general anaesthesia. 52 patients of ASA physical status I & II of either sex, aged 18–55 years, body weight between 42–78 kg and height 150–170 cm were recruited for this study. Patients with bleeding disorders, major hepatic, renal or cardiovascular dysfunction, pregnancy and taking anticoagulation therapy were excluded from the study. Patients were allocated randomly as per a computer generated simple randomization code to one of the two parallel groups. In NTG group, ($n = 26$) NTG and in ESM group ($n = 26$) esmolol was used to provide controlled hypotension. Allocation concealment was ensured with the use of sealed envelopes. A written informed consent was obtained from all the patients.

All patients were kept nil per oral night before surgery and received oral alprazolam (0.25–0.5 mg) in the night before surgery and 2 h prior to surgery. Intravenous access was obtained after shifting the patient to operation theatre and standard monitors including pulse oximeter, non invasive blood pressure, 5 lead electrocardiogram (ECG), end tidal CO₂ (EtCO₂) and temperature probes were attached and baseline values recorded. Each patient received a similar general anaesthesia using midazolam, glycopyrrolate and fentanyl intravenously for premedication 3–5 min before induction with propofol. Neuromuscular blockade to facilitate orotracheal intubation with appropriate sized cuffed tube was achieved by vecuronium and anaesthesia maintained on isoflurane, O₂, N₂O and fentanyl. All patients were mechanically ventilated through Bain's circuit maintaining appropriate tidal volume and EtCO₂. The patients were placed in 10° reverse Trendelenburg position to improve venous drainage. When a steady state of anaesthesia was attained (defined as a state of anaesthesia when no changes in hemodynamic variables took place for at least 10 min) the patients were administered hypotensive medication depending on the group allotted.

Patients in both groups received topical application of mixture of 4 ml lignocaine 2 % and 1 ml of epinephrine 1 in 1,000 on a well wrung out cotton pledges to the nasal mucous membrane, which was kept in situ for 10–15 min. After removal of pledges, lateral nasal wall was infiltrated with 0.5–1 ml of 1 % lignocaine with epinephrine 1 in 100,000–200,000 dilution before commencement of surgery.

In Group NTG patients, an intravenous infusion of NTG at a rate of 2–5 µg/kg/min was started from lower limit and titration was achieved with dosage increments every 5 min. The group ESM patients received esmolol initially as a bolus of 0.5 mg/kg, over a few minutes and then as an infusion titrated in increasing increments at a rate of 0.1–0.3 mg/kg/min. In both the groups mean arterial blood pressure (MABP) was reduced in steps of ~5 mmHg until the surgeon reported category scale of 2–3 or until a pre-determined lowest target MABP value of 60 mm of Hg was achieved. On attainment of target MABP or ACS of 2–3, this was maintained in the range by fine adjustment of infusion rate in each group. In both the groups the hypotensive drugs were continued till the procedure was completed. In all patients when MABP changed during hypotensive anaesthesia and remained at its value for 5–10 min, the surgeon assessed the ACS and the anaesthetist verified the observations at random intervals when blood pressure and pulse rate remained unchanged. The surgeon estimated the quality of operative field using a category scale (Table 1) adapted from Fromme et al. [10]. Average category scale (ACS) of 2 or 3 was judged to be optimal for surgery.

All operations were performed by one surgeon only to ensure consistency in estimation of the surgical field. The surgeon was blinded to the hypotensive agent being used, as well as to the monitor recording the hemodynamic variables. The amount of blood loss was determined by collecting the blood and rinsed fluid from the surgical field into the suction bottle by suctioning. The nurse who was not a part of the study made visual assessment of blood soaked gauge pieces consumed during surgery. The anaesthetist estimating the blood loss was blinded to the hypotensive agent being used. ECG monitoring was done continuously, for any changes in wave complexes, dysrhythmias and ischaemia. Heart rate, systolic, diastolic and mean arterial pressures were recorded immediately prior to induction of anaesthesia and subsequently every 3 min for 15 min and then every 5 min till the termination of anaesthesia. SpO₂, EtCO₂ and temperature were monitored continuously.

All patients received lactated ringer's solution at approximately 3–5 ml/kg/h perioperatively and normothermia was maintained during the whole procedure. At the conclusion of surgery, residual neuromuscular blockade was reversed with mixture of neostigmine and glycopyrrolate. The patients were extubated on recovery of adequate tidal volume and sufficient respiratory efforts and transferred to recovery room for observation.

To determine the optimum operative conditions in relation to MABP, the MABP recordings were analyzed in batches of 5 mmHg, hence three subgroups groups were formed in each group; MABP between 75–70 (mild hypotension), 69–65 and 64–60 mmHg.

Table 1 Average category scale for assessment of intra-operative surgical field bleeding

0	No bleeding
1	Slight bleeding-no suctioning of blood required
2	Slight bleeding-occasional suctioning required. Surgical field not threatened
3	Slight bleeding-frequent suctioning required. Bleeding threatens surgical field a few seconds: after suction is removed
4	Moderate bleeding-frequent suctioning required. Bleeding threatens surgical field directly after suction is removed
5	Severe bleeding-constant suctioning required. Bleeding appears faster than can be removed by suction. Surgical field severely threatened and surgery not possible

Sample size was calculated as 26 in each group, based on previous studies to achieve a power of 80 % and an alpha error of 0.05. Data were summarized in the form of median and standard deviations and were analysed and compared using Student's *t* test and Chi-square test. A *p* value <0.05 was considered significant.

Results

Patients in both groups were comparable in relation to age, sex, height, weight and duration of surgery (Table 2). The time to achieve target ACS of 2–3 was significantly shorter in ESM group compared to NTG group (4.02 ± 1.67 vs 6.26 ± 1.45). The intraoperative systolic, diastolic and MABPs did not differ significantly in both the groups when compared in three different subgroups depending on MABP ($p > 0.05$) (Table 3). The intraoperative heart rates remained lower in group ESM compared to group NTG (83.87 ± 7.58 vs 90.88 ± 8.54 , $p < 0.05$) (Table 3). Ideal operative condition (ACS of 2–3) in group ESM reached optimum levels (ACS 2.51 ± 0.52) early during titration of esmolol at MABP of 75–70. During early stages of titration of NTG, however and at the same level of MABP (75–70) the ACS was 3.48 ± 0.46 showing that more profound hypotension was required to acquire optimal surgical condition. In NTG group, ACS of 2–3 (mean 2.46 ± 0.28) was reached when MABP reduced to 65–60 mm of Hg in NTG group (Table 3). In our study ACS for group ESM was better than that of group NTG at all levels of MABP ($p < 0.05$) showing that esmolol provided better surgical conditions than NTG (Table 3). The average blood loss in group ESM was significantly less as compared to group NTG (172.47 ± 28.48 ml. vs 142.59 ± 24.46 ml in groups NTG and ESM respectively, $p < 0.01$) (Table 2). Blood transfusion was not required in any of the patients in either group. No significant complication of hypotensive anaesthesia was observed in any patient.

Discussion

The two groups were similar demographically. The mean duration of surgery was slightly less in ESM group. The surgical duration has been shown to be shorter when controlled hypotension technique is used [11] probably because of better visibility of surgical field and less time spent in repeated suctioning. Surgical bleeding is influenced by arterial and venous pressure as well as regional capillary circulation. During FESS capillary bleeding influences the operative field visibility most [12] and it can be reduced by providing hypotension and using local vasoconstrictors. NTG induces hypotension principally by dilating venous capacitance vessels, reducing both venous return and cardiac output. Arterial dilatation occurs in higher doses. Esmolol is B1 adrenoceptor antagonist, has short elimination half life and induces hypotension without causing tachycardia or rebound hypertension.

Both NTG and esmolol produced hypotension as required for FESS and MABP remained more or less in similar range in both the groups during the period of controlled hypotension. But optimum operative conditions as indicated by ACS of 2–3 (Mean $\pm$ SD, 2.51 ± 0.52) was attained with only minimum reduction in MABP (75–70 mmHg) with esmolol whereas similar operative conditions were reached with moderate reduction of MABP (69–60 mmHg) in patients where NTG was used. Our results are in agreement with previous study [4]. It is recommended that during controlled hypotension the aim should be to reduce the blood pressure minimally while providing best operative conditions [4]. Nair et al. [13] stated that premedication with B blockers provide better surgical conditions during FESS due to reduction in heart rate below 60 beats per minute. We achieved optimum conditions in esmolol treated patients even though the heart rate was more than 60 beats per minute. When hypotension is induced, it stimulates release of endogenous catecholamines. During esmolol induced hypotension, unopposed α -adrenergic effects (as a result of β -blockade by esmolol) causes vasoconstriction of arterioles & pre-capillary sphincters leading to less oozing at the operative site thus better quality of surgical field [4]. In contrast the endogenous catecholamines have minimal effect on vascular smooth muscles when NTG is used to induce hypotension, because of direct action of NTG on them. This may result in vasodilatation with consequent more oozing at surgical site. Reflex tachycardia may be a contributing factor [14]. Mean blood loss was significantly lesser in group ESM in comparison to group NTG (142.59 ± 24.46 vs 172.47 ± 28.48 ml in groups ESM and NTG respectively). This could probably be due to lower intraoperative heart rate which has been shown previously to reduce the amount of blood loss [13, 15]. Conversely, peripheral

Table 2 Demographic data and other variables

Parameters	Group NTG (<i>n</i> = 26)	Group ESM (<i>n</i> = 26)	<i>p</i> value
Age (year)			
Mean $\pm$ SD	35.45 $\pm$ 11.83	36.27 $\pm$ 12.42	0.808
Range	16–50	18–55	
Sex			
Male/female	15/11	14/12	0.780
Body weight (kg)			
Mean $\pm$ SD	56.42 $\pm$ 10.78	54.87 $\pm$ 11.24	0.614
Range	42–75	44–78	
Height (cm)			
Mean $\pm$ SD	161.43 $\pm$ 8.58	160.78 $\pm$ 8.38	0.783
Range	150–170	152–168	
Duration of surgery (min)			
Mean $\pm$ SD	95.75 $\pm$ 18.49	87.48 $\pm$ 15.87	0.090
Range	50–135	60–150	
Intraoperative blood loss (ml)			
Mean $\pm$ SD	172.47 $\pm$ 28.48	142.59 $\pm$ 24.46	0.01
Range	100–180	80–150	

Table 3 Haemodynamic variables and average category scale

MABP subgroup (mmHg)	Systolic blood pressure	Diastolic blood pressure	Mean arterial blood pressure	Heart rate/min	Category scale	<i>n</i>
Group NTG						
Base line	115.25 $\pm$ 16.33	63.17 $\pm$ 7.88	80.62 $\pm$ 12.14	98.0 $\pm$ 9.60	–	26
75–70	97.22 $\pm$ 5.25	57.84 $\pm$ 4.65	68.85 $\pm$ 2.14	90.88 $\pm$ 8.54	3.48 $\pm$ 0.46	12
69–65	88.54 $\pm$ 4.96	49.21 $\pm$ 5.28	66.44 $\pm$ 1.96	86.79 $\pm$ 5.84	2.89 $\pm$ 0.48	9
64–60	79.58 $\pm$ 5.38	46.25 $\pm$ 3.48	62.88 $\pm$ 2.05	81.22 $\pm$ 5.57	2.46 $\pm$ 0.28	15
Group ESM						
Base line	117.71 $\pm$ 15.28	64.67 $\pm$ 6.96	82.04 $\pm$ 16.91	97.0 $\pm$ 10.42	–	26
75–70	93.57 $\pm$ 5.76	61.85 $\pm$ 5.46	69.65 $\pm$ 2.08	83.87 $\pm$ 7.58*	2.51 $\pm$ 0.52*	13
69–65	85.67 $\pm$ 5.35	48.65 $\pm$ 5.64	68.26 $\pm$ 2.08	80.25 $\pm$ 6.06*	2.38 $\pm$ 0.42*	18
64–60	77.22 $\pm$ 5.04	46.94 $\pm$ 4.15	63.79 $\pm$ 2.11	69.48 $\pm$ 5.24*	2.02 $\pm$ 0.31*	16

Values are mean $\pm$ SD

n number of verified observations of ACS made following hemodynamic changes

* *p* < 0.05

vasodilatation associated with NTG might increase amount of bleeding [4, 12].

All the patients tolerated hypotension without any untoward adverse effect during surgery and in the post-operative period. After discontinuing hypotensive agent, arterial pressure restored to preoperative level over 3–5 min in each group. In none of the patients rebound hypertension or postoperative bleeding was noted.

To conclude, controlled hypotension is a vital tool during FESS due to improvement in surgical condition. The technique is simple, safe and easy to administer. Both esmolol and NTG are effective and safe drugs for this purpose. However, esmolol was better as it provided optimum surgical condition with only mild reduction in

blood pressure. Reduced intra operative bleeding and less tachycardia throughout the surgery were added advantages.

Conflict of Interest None.

References

1. Stammberger H (1986) Endoscopic endonasal surgery-concepts in treatment of recurring rhinosinusitis. Part II. Surgical technique. *Otolaryngol Head Neck Surg* 94:147–156
2. Stammberger H, Posawetz W (1990) Functional endoscopic sinus surgery: concept, indications and results of the Messerklinger technique. *Eur Arch Otorhinolaryngol* 247:63–76
3. Stankiewicz JA (1989) Complications of endoscopic sinus surgery. *Otolaryngol Clin North Am* 22:749–758

4. Boezaart AP, van der Merwe J, Coetzee A (1995) Comparison of sodium nitroprusside- and esmolol induced- controlled hypotension for functional endoscopic sinus surgery. *Can J Anesth* 42:373–376
5. Ankichetty SP, Ponniah M, Cherian VT, Thomas S, Kumar K, Jeslin L, Jeyasheela K, Malhotra N (2011) Comparison of total intravenous anaesthesia using propofol and inhalational anaesthesia using isoflurane for controlled hypotension in functional endoscopic sinus surgery. *J Anaesth Clin Pharm* 77:328–332
6. Pavlin JD, Colley PS, Weymuller EA Jr, Van Norman G, Gunn HC, Koerschgen ME (1999) Propofol versus isoflurane for endoscopic sinus surgery. *Am J Otolaryngol* 20:96–101
7. Tirelli G, Bigarini S, Russolo M, Lucangelo U, Gullo A (2004) Total intravenous anaesthesia in endoscopic sinus surgery. *Acta Otorhinolaryngol Ital* 24:137–144
8. Mandal P (2003) Hypotensive anaesthesia with remifentanyl for functional endoscopic sinus surgery. *J Anaesth Clin Pharmacol* 19:411–415
9. Ahn HJ, Chung SK, Dhong HJ, Kim HY, Ahn JH, Lee SM, Hahm TS, Kim JK (2008) Comparison of surgical conditions during propofol or sevoflurane anaesthesia for endoscopic sinus surgery. *Br J Anaesth* 100:50–54
10. Fromme GA, MacKenzie RA, Gould AB, Lund BA, Offord KP (1986) Controlled hypotension for orthognatic surgery. *Anesth Analg* 65:683–686
11. Cincikas D, Ivaskevicius J (2003) Application of controlled arterial hypotension in endoscopic rhinosurgery. *Medicina* 9:852–859
12. Jacobi KE, Bohm BE, Richauar AJ, Jacobi C, Hemmerling TM (2000) Moderate controlled hypotension with sodium nitroprusside does not improve surgical condition or decrease blood loss in endoscopic sinus surgery. *J Clin Anesth* 12:202–207
13. Nair S, Collins M, Hung P, Rees G, Close D, Warmald PJ (2004) The effect of beta-blocker premedication on the surgical field during endoscopic sinus surgery. *Laryngoscope* 114:1042–1046
14. Kamal HM, Abdel-Rahman ASH (2008) Clevidipine for deliberate hypotension in functional endoscopic sinus surgery (FESS). *EJCTA* 2:158–164
15. Eberhart LH, Folz BJ, Wulf H, Geldner G (2003) Intravenous anaesthesia provides optimal surgical conditions during microscopic and endoscopic sinus surgery. *Laryngoscope* 113:1369–1373