CONTROLLED HYPOTENSION IN ENDOSCOPIC SINUS SURGERY: COMPARATIVE STUDY BETWEEN THE EFFICACY OF ESMOLOL , SODIUM NITROPRUSSIDE AND MAGNESIUM SULPHATE

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ABSTRACT

Background: This prospective study was designed to compare the efficacy of esmolol, sodium nitroprusside (SNP) and magnesium sulphate ($MgSO_4$) for producing controlled hypotension in patients submitted for Endoscopic Sinus Surgery (ESS).
Methods: This study was conducted on sixty normotensive ASA I and II patients of either sex, aging 20-50 years, subjected to undergo elective ESS in Zagazig University Hospital during the period from April 2010 to March 2011 after obtaing the ethics committee approval and the patients informed consent. Patients with history of cardiovascular, renal, central nervous system, hepatic or pulmonary dysfunction, or those receiving any medications known to interfere with autonomic control of cardiovascular functions were excluded from the study. The patients were randomly allocated into three groups. Group I: Patients received Esmolol as IV bolus application of 500 ug / kg, followed by continuous infusion at a rate of 100-300 ug/ kg/ min. Group II: Patients received SNP as starting rate of IV infusion of 1 ug/ kg/min, then, continuous IV infusion rate of 1-10 ug /kg/min. Group III: Patients received $MgSO_4$; 40 mg/ kg administered as a slow i.v bolus over a 10 min period before the induction of anesthesia, then, 15 mg/ kg/ h by continuous IV infusion during the operation.
Results: The SBP, DBP and MAP were significantly decreased by the three different hypotensive agents. In the SNP group, we found a significant increase in HR, while the hypotensive effects of both esmolol and $MgSO_4$ groups were associated with significant decreases in the HR. There was statistically significant decrease of the blood loss in both esmolol and $MgSO_4$ groups as compared to SNP group. There was a statistically significant decrease in esmolol group than in SNP and $MgSO_4$ groups as regards the average category scale (ACS) score. There were no significant differences between the three groups regarding the duration of starvation, while there was statistically significant increase of the duration of surgery in the SNP group when compared to the esmolol and $MgSO_4$ groups.
In conclusion: The use of esmolol or $MgSO_4$ was associated with a better quality of the operative field and decreased operative time and blood loss than the use of SNP. Also, esmolol was superior to $MgSO_4$ as a hypotensive agent used in those patients undergoing ESS.
Key words: Controlled hypotension, ESS, Esmolol, SNP, $MgSO_4$, SBP, DBP, MAP, ACS.

INTRODUCTION

With modern anesthesia and perioperative care, major complications after anesthesia are rare. Such complications result from intervention of anesthesia and surgery rather than from underlying disease[(1)]. Bleeding is a major concern in ESS, as it may impede surgical progress and is often associated with complications[(2)].

Anesthetic management during ESS is aimed at minimizing bleeding and establishing a near perfect surgical field, thus improving the operating conditions[(3)]. Deliberate hypotensive anesthesia was found to significally decrease blood loss, reduce the need for blood transfusion and shorten the operating time[(4)].

Controlled hypotension is defined as a reduction of the systolic blood pressure (SBP) to 80-90 mm Hg, a reduction of mean arterial pressure (MAP) to 50-65 mm Hg in normotensive patients or a 30% reduction of baseline MAP[(5)]. It is broadly achievable by vasodilatation and /or reduced myocardial contractility. Various inhalational agents (Halothane, isoflurane, sevoflurane), and intravenous (IV) agents (pentamethonium iodide, nitroglycerin, labetalol, esmolol, adenosine) are usually used to achieve this hypotension. Best attempt is made to maintain adequate organ perfusion at low perfusion pressure (during hypotensive state)[(6)].

There is general consensus that when ESS is performed under general anesthesia, maintaining moderate controlled hypotension (MAP 60-70 mmHg) is important in improving visibility in the operative field which result in faster surgery and reduced risk of such major complications as massive hemorrhage, skull base defect, orbital hemorrhage and blindness[(7)].

The use of $MgSO_4$ as an agent for controlled hypotension in ESS demonstrated that $MgSO_4$ led to a reduction in arterial pressure, HR, blood loss and duration of surgery[(8)]. Esmolol is an ultra short-acting selective β_1 adrenergic receptor blocking drug that reduces HR and, to a lesser extent, blood pressure[(9)]. It is effective as a sole agent for producing controlled hypotension[(10)]. SNP is a direct acting, non selective peripheral vasodilator that causes relaxation of arterial and venous vascular smooth muscle. The ability of SNP to rapidly and predictably decrease MAP to desired levels makes this vasodilator a useful drug, especially during operations requiring nearly a bloodless field as well as decreasing transfusion requirements[(11)].

This prospective randomized study was designed to compare the efficacy of esmolol, SNP and $MgSO_4$ for producing controlled hypotension in patients submitted for ESS.

PATIENTS AND METHODS

After approval of the local Ethical Committee, a written informed consent was obtained from every patient. This prospective randomized study was conducted on sixty normotensive ASA I and II patients of either sex, aging 20-50 years and subjected to undergo elective ESS in Zagazig University Hospital during the period from April 2010 to March 2011. All patients were preoperatively evaluated in the ward for routine history taking, complete clinical examination, ECG, and basal laboratory investigations (complete blood count, blood sugar, kidney function tests, liver function tests, coagulation profiles). Patients with history of cardiovascular, renal, central nervous system, hepatic or pulmonary dysfunction, or those receiving any medications known to interfere with autonomic control of cardiovascular functions were excluded from the study.

All patients were premedicated with IV midazolam 1-3 mg, after insertion of an IV cannula (18G) and then transferred to the operating room. Under local lidocaine anesthesia, a 22-gauge arterial cannula was inserted into a radial artery for direct measurement of ABP (SBP, DBP, and MAP) and HR. While the patients were rested on the operating table, the monitors were fixed to them for monitoring of SBP, DBP, MAP, HR, ECG and oxygen saturation.

All Patients were preoxygenated for 2 minutes before induction of anesthesia, and then anesthesia was induced by 2.5 mg/kg of propofol intravenously (20 mg lidocaine was injected before propofol to lessen the pain during injection) and IV fentanyl 1-2 ug/kg. Cisatracurium (0.16 mg/kg IV) was administered followed by face mask ventilation for 30-90 seconds to facilitate endotracheal intubation (with a suitable size, cuffed endotracheal tube) and oropharangeal pack was placed. The patients' lungs were mechanically ventilated to maintain an end tidal carbon dioxide tension (PET CO_2) at 30-35 mm Hg. All patients were catheterized with foley catheter for urine output monitoring. All patients were placed in a 30 degrees head up tilt aimed at to increase venous drainage, keep venous pressure low and decrease venous congestion of the region of head and neck, so decreasing venous bleeding. Anesthesia was maintained with isoflurane 0.5-1% in oxygen in all groups.

Intraoperative muscle relaxation was achieved with incremental doses of cisatracurium (20% of the induction dose) that were given when needed. Strict intraoperative fluid management included replacement of deficit, third space loss (3 ml/kg/hr), blood loss (3:1 ratio), and urine output using isotonic saline and ringer' solutions. After hemodynamic stability for at least 10 minutes, the patients were randomly assigned to three equal groups (20 patients each) to receive esmolol (group I), SNP (group II) or $MgSO_4$ (group III) for inducing controlled hypotension.

Esmolol was given as IV bolus application of 500 ug/kg, followed by continuous infusion at a rate of 100-300 ug/kg /min. SNP was given as starting rate of IV infusion of 1 ug/kg/min, then, continuous IV infusion rate of 1-10 ug/kg/min. $MgSO_4$ was given as a slow IV bolus of 40 mg/kg over a 10 min period before the induction of anesthesia, then, 15 mg/kg/h by continuous IV infusion during the operation.

Our aim was to maintain MAP between 50-65 mmHg before skin incision. When the MAP reached the estimated level and maintained for at least 15 minutes, the surgeon evaluated the quality of the operative field using a predefined average category scale (ACS) adopted from that of Fromme et al.[12] (Table 1). Intraoperative blood loss was estimated by measuring the contents of the suction bottle after subtraction of the amount of saline used for irrigation, and by assessment of the surgical gauze swab and hemodynamic variables were estimated which included HR and ABP (SBP, DBP and MAP) that were recorded using the invasive blood pressure measurement through the intraarterial catheter. The ideal target was to maintain the surgical field within a score of 2 to 3. The surgeons were blinded to the hypotensive agent used.

Table (1): Average category scale (ACS)[12]

Score	Surgical Field
0	No bleeding.
1	Slight bleeding. No suction of blood is required.
2	Slight bleeding. Occasional suction is required. Surgical field is not threatened.
3	Slight bleeding. Frequent suction is required. Bleeding threatens surgical field a few seconds after suction is removed.
4	Moderate bleeding. Frequent suction is required. Bleeding threatens surgical field directly after suction is removed.
5	Severe bleeding. Constant suction is required. Bleeding appears faster than can be removed by suction. Surgical field is severely threatened and surgery not possible.

At the end of the procedure, discontinuation of isoflurane and reversal of the muscle relaxation with neostigmine (0.05mg/kg) and atropine (0.02 mg/kg) were done. In the $MgSO_4$ group, patients were given additionally 10 ml of 10% calcium gluconate. All patients were extubated in the operating room and were discharged to the recovery room, where they were placed on oxygen mask. The intra-arterial catheter was removed with compression for at least five minutes at the site of puncture to prevent the formation of a hematoma. All patients were observed in the recovery room for 1-2 hrs to detect any hemodynamic changes, and to detect any postoperative complications that may be present.

Statistical analysis:

The data were tabulated and statistically analyzed using a computer presentation of data using the Statistically Package for Social Science; (SPSS) version 15. The numerical variables are presented as the arithmetic mean ± the standard deviation (SD) and categorical variables were presented as number and percentage. The analysis was done using Chi-square (X^2) test to find the association between categorical variables. Kolmogorov Simirnov test was used to test for normality of distribution of variables. In normally distributed variables, ANOVA (F) test with Bonferroni multiple comparisons were used for intergroup comparisons. Paired sample t-test was used for comparison within the same group. P value <0.05 was considered statistically significant.

RESULTS

As regards the differences in age, gender, body weight (BW) and height (HT), there were no significant differences between the three groups as shown in table 2, figure 1 and figure 2.

There were no significant differences between the three groups as regards the duration of starvation, while There was statistically significant increase of the duration of surgery in the SNP group when compared with the esmolol and $MgSO_4$ groups and there was statistically significant increase of the duration of surgery in the $MgSO_4$ group when compared with the esmolol as shown in table 3 and figure 3.

In the present study, SBP, DBP and the MAP were significantly decreased by the three different hypotensive agents**.** Regarding HR, in the SNP group, we found a significant increase in HR, while the hypotensive effects of both esmolol and $MgSO_4$ groups were associated with significant decreases in the HR.

There were statistically significant decreases in the blood loss in both esmolol and $MgSO_4$ groups as compared to SNP group. Also, there was statistically significant decrease in the blood loss in esmolol group compared with $MgSO_4$ group as shown in table 8 and figure 4.

Table (2): Demographic data.

	I	II	III	F	P
Age (Years)					
Mean ± SD	30.1 ± 7.4	29.6 ± 7.5	31.7 ± 9.2	0.36	0.69
Range	18-42	18-45	18-50		
Gender					
Male	9 (45%)	8 (40%)	11 (55%)	0.94	0.62
Female	11 (55%)	12 (60%)	9 (45%)		
Body weight (Kg)					
Mean ± SD	86.75 ± 13.9	88.1 ± 18.4	80 ± 11.8	1.67	0.19
Range	66-120	62-130	65-110		
Height (Cm)					
Mean ± SD	167.9 ± 10	169.3 ± 9.1	166.7 ± 8.4	1.1	0.12
Range	155-190	152-186	150-180		

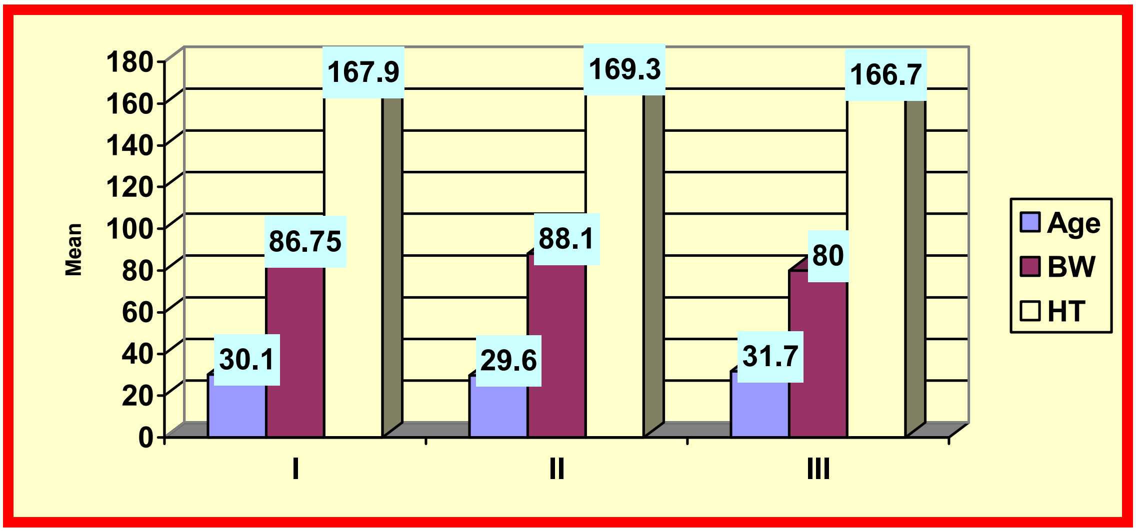

Figure 1: Age (Years), body weight (Kg) and height (Cm).

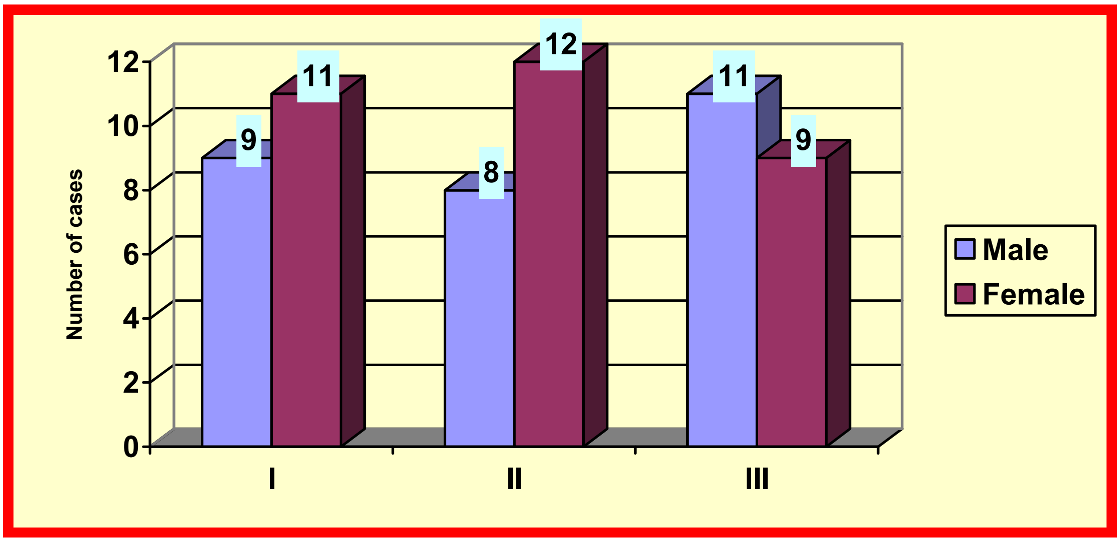

Figure 2: Gender.

Table 3: Operative data

	Group I	Group II	Group III	F	P
Duration of starvation (hr)					
Mean ± SD	9.1 ± 1.1	9.5 ± 1.3	8.8 ± 0.9	2.25	0.11
Range	8-11	8-12	8-11		
Duration of surgery (min)					
Mean ± SD	70.5 ± 21	94.5 ± 21.7	81 ± 23	5.99	0.004
Range	45-110	45-120	40-120		

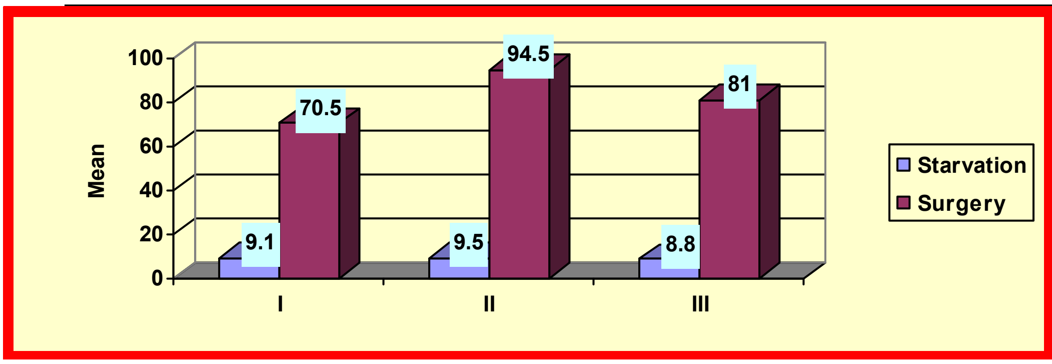

Figure (3): Operative data.

Table (4): SBP changes (mmHg).

	Group I Mean ± SD (range)	Group II Mean ± SD (range)	Group III Mean ± SD (range)	F	P
T_0	123.5 ± 9.9 (110-140)	127.2 ± 13.9 (100-150)	124.4 ± 11.4 (110-140)	0.54	0.58
T_1	100 ± 9.7 (90-120)	114.5 ± 14.3 (90-140)	109.2 ± 11.95 (90-130)	7.3	0.001
T_2	87.5 ± 7.1 (80-100)	103 ± 12.6 (80-120)	98.5 ± 12.2 (80-120)	10.58	< 0.001
T_3	76.8 ± 4.8 (70-80)	93.1 ± 10 (80-110)	89.4 ± 9 (80-110)	17.47	< 0.001
T_4	69.3 ± 1.9 (65-70)	84.1 ± 11.1 (70-100)	82.3 ± 7.5 (70-90)	7.07	0.002
T_5	-	77.5 ± 12.5 (60-90)	70 ± 0	0.53	0.63
T_E	94.5 ± 8.2 (80-120)	92.6 ± 12.4 (80-120)	93.5 ± 10.8 (80-110)	0.99	0.35
T_R	108 ± 11.7 (80-130)	106.9 ± 13.4 (80-130)	107.5 ± 8.9 (90-130)	0.23	0.78

Table (5): DBP changes (mmHg).

	Group I Mean ± SD (range)	Group II Mean ± SD (range)	Group III Mean ± SD (range)	F	P
T_0	75.5 ± 6 (70-90)	77.5 ± 10.7 (60-100)	80.6 ± 9.3 (70-90)	1.66	0.19
T_1	63.5 ± 7.5 (50-70)	71 ± 11.6 (60-90)	68.75 ± 7.9 (60-80)	3.49	0.03
T_2	51 ± 10.7 (40-70)	62.5 ± 10.7 (40-80)	60.5 ± 9.98 (40-80)	6.88	0.002
T_3	40 ± 3.6 (30-50)	55.3 ± 11.7 (40-80)	52.9 ± 8.7 (40-60)	14.25	< 0.001
T_4	41.4 ± 3.8 (40-50)	49.4 ± 11.9 (40-80)	48.5 ± 8.2 (40-60)	1.84	0.17
T_5	-	41.2 ± 2.5 (40-45)	40 ± 0	0.44	0.68
T_E	61 ± 6.4 (40-70)	58.6 ± 11.5 (40-90)	59.2 ± 9.1 (40-70)	0.66	0.51
T_R	71.5 ± 6.4 (60-80)	69 ± 11.2 (60-95)	70 ± 8.1 (60-90)	0.01	0.98

Table (6): MAP changes (mmHg).

	I Mean ± SD (range)	II Mean ± SD (range)	III Mean ± SD (range)	F	P
T_0	91.1 ± 6.4 (83.3-106.6)	92.8 ± 8.9 (80-110)	95.1 ± 9.7 (83.3-106.6)	1.16	0.31
T_1	75.3 ± 6.98 (63.3-86.6)	82.2 ± 9.5 (70-103.3	81.4 ± 8.4 (70-96.6)	3.94	0.02
T_2	62.9 ± 9.4 (53.3-80)	76.3 ± 10.1 (53.3-103.3)	72.1 ± 9.1 (53.3-86.6)	10.13	< 0.001
T_3	52.3 ± 3.4 (43.3-60)	66.9 ± 12.6 (50-93.3)	64 ± 8.5 (53.3-76.6)	11.79	< 0.001
T_4	50.6 ± 2.7 (48-56.6)	62.5 ± 11.6 (50-86.6)	57.8 ± 7.4 (50-70)	4.04	0.02
T_5	-	60.6 ± 11.8 (40-70)	60 ± 0	0.04	0.96
T_E	72.1 ± 6.5 (53.3-86.6)	70 ± 10.1 (53.3-90)	71.1 ± 10.9 (53.3-103.3)	0.13	0.87
T_R	83.2 ± 6.7 (70-96.6)	81.5 ± 10 (70-103.3)	82.6 ± 8.4 (60-96.6)	0.25	0.77

Table (7): HR changes (beat/min).

	Group I Mean ± SD (range)	Group II Mean ± SD (range)	Group III Mean ± SD (range)	F	P
T_0	83.9 ± 5.6 (62-100)	83.7 ± 10.2 (60-100)	84.3 ± 8.7 (65-100)	1.1	0.19
T_1	71.8 ± 7.65 (65-90)	92.3 ± 8 (75-110)	74.9 ± 9.4 (60-90)	24.5	< 0.001
T_2	67.9 ± 4.9 (55-75)	97 ± 10.9 (70-115)	70 ± 7.3 (55-82)	92.7	< 0.001
T_3	62.5 ± 2.4 (60-65)	106.3 ± 10.5 (85-120)	62.5 ± 4.8 (55-71)	36.5	< 0.001
T_4	58.3 ± 2.4 (55-60)	111.9 ± 9.4 (92-125)	61± 8.1 (55-85)	26.09	< 0.001
T_5	-	114.3 ± 12.9 (100-125)	55 ± 0	1	0.17
T_E	73.7 ± 4.2 (69-85)	101 ± 10.2 (70-115)	65.5 ± 4.6 (60-72)	45	< 0.001
T_R	81.6 ± 5.5 (70-90)	91.5 ± 11.2 (65-115)	76.6 ± 6.7 (62-90)	21.7	< 0.001

Table (8): Blood loss (ml).

	I	II	III	F	P
Blood loss (ml)					
Mean ± SD	165 ± 42.6	320 ± 73.3	286.5 ± 99.8	23.2	< 0.001
Range	100-250	200-450	100-450		

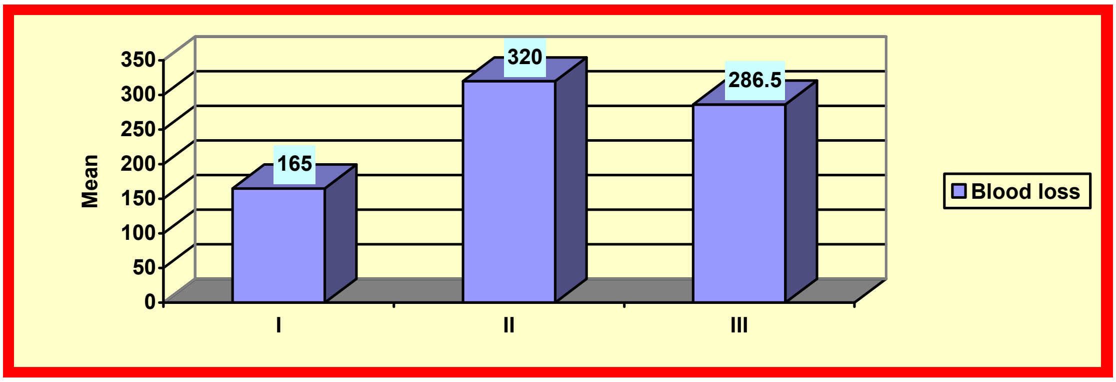

Figure (4): Blood loss (ml)

Table (9): ACS changes.

	I	II	III	F	P
15 minutes					
Mean ± SD	2.65 ± 0.49	3.9 ± 0.3	3.4 ± 0.5	40.4	< 0.001
Range	2-3	3-4	3-4		
30 minutes					
Mean ± SD	1.7 ± 0.47	3.2 ± 0.7	2.7 ± 0.8	25.9	< 0.001
Range	1-2	2-4	2-4		
60 minutes					
Mean ± SD	1.1 ± 0.7	2.5 ± 0.76	2 ± 1.06	14.06	< 0.001
Range	0-2	0-3	0-3		
90 minutes					
Mean ± SD	0.4 ± 0.6	1.95 ± 1.1	1.05 ± 1.01	16.7	< 0.001
Range	0-2	0-3	0-3		
120 minutes					
Mean ± SD	-	0.2 ±0.6	0.1 ± 0.4	1.03	0.36
Range	-	0-2	0-2		

DISSCUSION

Over the past decade, surgical management of rhinosinusitis had completely changed. The ability to see the site of disease within the nose and paranasal sinuses clearly has allowed the surgeons to develop more meticulous and thorough surgical techniques to remove diseased tissue and leave the nose functionally stable[(13)]. As ESS is a delicate and time consuming procedure, it is performed under general anesthesia[(14)]. During ESS, mucosal bleeding often interferes with the optimal visualization of intra nasal anatomy, which not only hinders the operation but also increases the incidence of complications. For an appropriate control of intraoperative bleeding, various maneuvers such as an epinephrine injection into the nasal mucosa, elevation of the patients' head, or controlled hypotension have been adopted[(15)]. Controlled hypotension is a technique that is used to limit intraoperative blood loss to provide the best possible field for surgery[(16)].

This study aimed at comparing the efficacy of esmolol, SNP and $MgSO_4$ in inducing controlled hypotension during ESS under general anesthesia as regards perioperative hemodynamics, intraoperative blood loss and visibility of operative field. Esmolol has been used successfully to induce hypotension in ESS[(9,14,17)] and tympanoplasty[(16, 18)]. SNP has been used successfully to induce hypotension in ESS[(9, 14,17,19)]. $MgSO_4$ has been used successfully to induce hypotension in cerebral aneurysm surgery[(20)], major oral and maxillofacial surgeries[(21)], rhinoplasty[(22)], ESS[(8)] and choridal melanoma resection surgery[(23)].

In our study the SBP, DBP and MAP displayed a significant decrease in esmolol and $MgSO_4$ groups than SNP group at 15, 30, 60 and 90 minutes, while intraoperative readings of SBP, DBP and MAP were lower in $MgSO_4$ group than SNP group at 120 minutes, duration of surgery of the esmolol group not reached 120 minutes which indicated the decrease in the duration of surgery in esmolol group in comparable to SNP and $MgSO_4$ group. All intraoperative readings of SBP, DBP and MAP were lower in esmolol group than $MgSO_4$ group. While, at the end of surgery and immediately after recovery values of SBP, DBP and MAP in $MgSO_4$ group were lower than in esmolol group but with no significant value, which indicated the advantage of increase of SBP, DBP and MAP of esmolol group with stoppage of esmolol infusion compared to $MgSO_4$ group, meanwhile at the end of surgery and immediately after recovery, values of SBP, DBP and MAP in SNP group were low when compared to esmolol and $MgSO_4$ groups, but with no significant differences, which indicated prolonged duration of action of SNP compared to esmolol and $MgSO_4$ group, which has the disadvantage of continuity of hypotension for sometime after stoppage of SNP infusion when compared to esmolol and $MgSO_4$.

The use of esmolol in this study to achieve MAP between 50-65 mmHg during the hypotensive technique is supported by Pilli et al.[(24)], who stated that esmolol could be used as an agent for improving the quality of controlled hypotension to get a bloodless field during the middle ear surgery. When all SBP, DBP and MAP values were registered, significant decreases in these hemodynamic values were found and the operative field was virtually bloodless. Esmolol was notified as an appropriate agent for controlled hypotension because it showed no side effects, it was easy to control administration and it provided the desired degree of hypotension without complications.

The results of the present study as regards the use of esmolol, SNP or $MgSO_4$ as agents for controlled hypotension and comparing their effects on hemodynamic values, are consistent with the results of other studies in which controlled hypotension was induced. The results of this study agrees with the results obtained by Mengistu et al.[(17)], who studied the influence of controlled hypotension during esmolol and SNP on nitric peptides in patients undergoing ESS, they recorded significant decrease of MAP during surgery, however, at the end of surgery, the SNP group showed a higher MAP compared to esmolol group. Kumar et al.[25] compared the efficacy of IV esmolol, deltiazem and $MgSO_4$ in attenuating hemodynamic response to laryngoscopy and tracheal intubation and they found significant fall in SBP and DBP in esmolol group. However, in contrast to our study SBP and DBP in $MgSO_4$ group showed insignificant fall. El sharnouby and El sharnouby[8] studied the efficacy of $MgSO_4$ as a technique of controlled hypotension during ESS and they found a significant decrease of MAP, HR, blood loss and duration of surgery.

It is reasonable to conclude that hypotensive effect of esmolol is superior to the other two hypotensive agents as regard to decreases of SBP, DBP and MAP.

HR displayed significant decreases in esmolol and $MgSO_4$ groups compared to SNP group at 15, 30, 60 and 90 minutes. The duration of surgery in the esmolol group was less than 120 minutes, which indicated the decrease in the duration of surgery in esmolol group when compared with SNP and $MgSO_4$ groups. In the SNP group, HR displayed a significant increase as compared to its basal value. Also, HR was lower in esmolol group than $MgSO_4$ group at 15, 30, 60 and 90 minutes, but with no significant difference. At the end of surgery and immediately after recovery, values of HR in $MgSO_4$ group were lower than in esmolol group but with no significant differences, which indicated the advantage of increase of HR in esmolol group with stoppage of esmolol infusion as compared to $MgSO_4$ group.

Yaster et al.[26], compared both nitroglycerin and SNP for induction of hypotension and revealed that both drugs produced an increase in HR which was thought to be a reflex sympathetic nervous system response mediated by catecholamine[27] and the renin angiotensin system[28].

Yosry and Othman[23], compared both $MgSO_4$ and SNP for induction of controlled hypotension in choroidal melanoma resection surgery and revealed that $MgSO_4$ was associated with significant decrease of HR from baseline compared to SNP that was associated with significant increase of HR.

The reduction in HR during esmolol and during $MgSO_4$ induced hypotension was noticed in our study and other studies suggested that both drugs might be superior to SNP that caused reflex tachycardia[8,16,18,23,29,30,31,32,33].

Several studies found a significant decrease of HR with esmolol[17,29,30,31,32,33]. Meanwhile, the hypotensive effect of SNP was associated with increased HR[17,29]. In a recent study by Kol et al.[16]**,** they found that esmolol was associated with significant decrease of HR during the hypotensive period compared with at baseline, after induction and at end of surgery. Esmolol induced hypotension was suggested to be due to both negative inotropic and negative chronotropic effects of the drug[38]**.**

In our study, $MgSO_4$ induced hypotension was not associated with tachycardia. This agrees with the results reported by El sharnouby and El sharnouby[8], who studied the use of $MgSO_4$ as a hypotensive agent in ESS. There were no rebound hypertension or reflex tachycardia with $MgSO_4$ infusion, probably because hypermagnesemia was associated with inhibition of angiotensin converting enzyme activity, sympathetic blockade, slowing of sinoatrial node transmission, depression of carotid baroreceptors and diminished releases of catecholamines[35]. This also agrees with the results obtained by Yosry and Othman[23].

In contrast to our results, it has been

reported that $MgSO_4$ infusion was associated with mild tachycardia when used to attenuate stress response of endotracheal intubation in patient with CAD[25,36] or for hypotensive anesthesia in rhinoplasty[22]. This was explained by the fact that $MgSO_4$ inhibits the release of acetylcholine from the vagus nerve which predominates over its bradycardiac effect due to slowing of the atrial rate[37].

It is reasonable to conclude that hypotensive effect of esmolol is superior to the other two hypotensive agents as regard to decrease of HR, while in the SNP group; HR displayed a significant increase as compared to its basal value. Also, all intraoperative readings of HR were lower in esmolol group than $MgSO_4$ group; meanwhile, all postoperative readings of HR in $MgSO_4$ group were lower than in esmolol group, which indicated the advantage of increase of HR in esmolol group with stoppage of esmolol infusion compared to $MgSO_4$ group.

Controlled hypotension is used to help control of bleeding during procedures where surgical hemostasis is technically difficult to achieve (e.g. operations on hip, spine or facial bones). A MAP as low as 50-60 mmHg appears to be well tolerated in healthy patients. The benefits of controlled hypotension include a decrease in operating time, a reduction in blood loss[38], with decreased transfusion requirements[39] and improved quality of the surgical field[40].

In our study, there were statistically significant differences between the operative times using the three hypotensive agents. There was a statistically significant increase of the duration of surgery in the SNP group when compared to the esmolol and $MgSO_4$ groups and there was a statistically significant increase of the duration of surgery in the $MgSO_4$ group when compared to the esmolol. El sharnouby and El sharnouby[8] studied the efficacy of $MgSO_4$ as a technique of controlled hypotension during ESS and they found a significant decrease in the duration of surgery. Also, Mengistu et al.[17], who found that the duration of surgery was significantly longer in control group that received saline solution as placebo when compared to hypotensive group that used esmolol and SNP. However, in contrast to our results, Boezaart[9], who compared the SNP and esmolol as drugs for controlled hypotension during ESS, found that there was no difference in duration of surgery between the groups.

In our study, there was significant decreases in blood loss in both esmolol and $MgSO_4$ groups compared to SNP group; also there was a statistically significant decrease of the blood loss in esmolol group compared with $MgSO_4$ group. El sharnouby and El sharnouby[8] found a significant decrease in blood loss, when they used $MgSO_4$ as a technique of controlled hypotension during ESS. Boezaart[9] found that blood loss was minimal in esmolol and SNP groups for controlled hypotension during ESS and no patient required blood transfusion or presented with excessive postoperative bleeding. Jacobi et al.[19], who used SNP as an agent for controlled hypotension during ESS, found that blood loss was higher in SNP group, though not to a statistically significant degree, as compared to normotensive group. Lim et al.[41], used esmolol for controlled hypotension in patients undergoing spinal surgery; they reported that esmolol was an appropriate agent for controlled hypotension for prevention of blood loss in patients of the study except those who were not with cardiovascular problems. Mengistu et al.[17]**,** found that blood loss in both hypotensive groups; esmolol and SNP was significantly lower compared with the control group that received saline solution as placebo.

Schaberg et al**.**[42], found that blood loss could be decreased by more than 40% during hypotensive anesthesia, compared with normotensive anesthesia for similar orthognathic operations by lowering the

MAP from a preoperative level of 90 mmHg to an intraoperative level of 70 mmHg. Also, Chan et al.[43], showed that, during maxillary segmental osteotomy, lowering of MAP to at least 80% of the preoperative value reduced blood loss by 41%. Similarly, another study concluded that there was a pronounced reduction in blood loss during orthognathic operations done under hypotensive anesthesia compared with those done under normotensive anesthesia[44].

Recently, Varol et al.[45], concluded that blood transfusion in bimaxillary osteotomies could be prevented by induction of moderate hypotension with MAP of 55-60 mmHg in Le Forte I osteotomies, however, there are controversies surrounding blood loss during hypotensive anesthesia.

In contrast to our results, Lessard et al.[40], found no particular advantage in using hypotensive anesthesia for orthognathic operation, another study by Felfering-Boehm et al.[46], concluded that induction of hypotension during orthognathic operations with use of remifentanil or nitroglycerin did not result in reduced blood loss when compared with normotensive anesthesia.

Miller[47], demonstrated that healthy patients with a hematocrit value more than 30% rarely require perioperative blood transfusion, whereas patients with acute anaemia (as in intraoperative blood loss) of a hematocrit value less than 21% frequently require blood transfusion. Consequently, the blood loss in our study was believed to be within the physiological limits and the blood transfusion was considered not indicated.

Assessment of the quality of the surgical field was achieved using a predefined ACS adopted from that of Fromme et al.[12]. In this study the esmolol group was better than $MgSO_4$ group and SNP group as regard the visibility of the surgical field. Also $MgSO_4$ resulted in a better visibility of the surgical field compared to SNP in patients of each group.

The results of the present study as regards the quality of the surgical field are consistent with the results of other studies in which controlled hypotension was induced. The results of our study agree with the results obtained by Crozier et al.[20], during cerebral aneurysm surgery, in which $MgSO_4$ was found to provide a dry field and reduced intraoperative bleeding, without reflex tachycardia, rebound hypertension or CO reduction. Also, Boezaart et al.[9], compared surgical conditions of ESS under general anesthesia during controlled hypotension using either SNP or esmolol. They found that better surgical conditions were provided with minimal esmolol controlled hypotension (MAP > 65 mmHg). On the other hand, SNP induced hypotension did not provide good surgical field until severe levels of hypotension were present (MAP of 50-54 mmHg).

Degoute et al.[48] assessed the quality of the surgical field using the ACS after induction of hypotensive anesthesia using remifentanil, esmolol and SNP, they found that remifentanil and esmolol provided better field than SNP and this was explained by their inhibitory effects on sympathetic stimulation induced by stress. Also, Badawy et al.[22], found that moderate hypotension with either esmolol or $MgSO_4$ provided a surgically dry and bloodless operative field. In addition, Yosry and Othman[23], when comparing the surgical condition of choroidal melanoma resection under general anesthesia during controlled hypotension using either SNP or $MgSO_4$, they found that $MgSO_4$ was effective in inducing consistent and sustained controlled hypotension and provided good surgical condition compared to SNP due to reduction of HR and blood pressure.

Hassan et al.[34] assessed the quality of the surgical field for middle ear surgery during controlled hypotension and they found that esmolol was effective in providing optimal surgical field and hemodynamic stability. Furthermore, Kol et al.[16], assessed the quality of the surgical field using the ACS after induction of hypotensive anesthesia using desflurane combined with dexmedetomidine or esmolol during tympanoplasty and they found that scores for a bloodless surgical field were low in both groups and there was no significant difference between the scores of both groups.

The results of this study demonstrated that controlled hypotension, irrespective of the agents used, showed a trend to a reduced intraoperative blood loss, a reduced operative time and an improved quality of the surgical field.

From this study, it was concluded that achieving controlled hypotension resulted in useful reduction in blood loss and duration of surgery in those patients undergoing ESS. In addition, the usage of esmolol, SNP or $MgSO_4$ was effective and well tolerated in achieving controlled hypotension to limit the amount of blood in the surgical field with its better visibility during ESS. Furthermore, esmolol was associated with significanly decreased ASC score and blood loss with lower HR and MAP compared with $MgSO_4$ and SNP during controlled hypotension in those adult patients undergoing ESS.

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