THE ROLE OF HYPOTENSIVE ANAESTHESIA IN ORTHOGNATHIC SUGERY

Dissertation Submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the Degree of

MASTER OF DENTAL SURGERY

BRANCH III

ORAL MAXILLOFACIAL SURGERY

APRIL 2013

CERTIFICATE

This is to certify that this dissertation titled **"THE ROLE OF HYPOTENSIVE ANAESTHESIA IN ORTHOGNATHIC SURGERY"** is a bonafide record of work done by **Dr.G.Manikandan** under our guidance and to our satisfaction during his postgraduate study period **2010-2013**.

This Dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY,** in partial fulfillment for the award of the Degree of **MASTER OF DENTAL SURGERY – ORAL AND MAXILLOFACIAL SURGERY, BRANCH III.** It has not been submitted (partial or full) for the award of any other degree or diploma.

Guided by:

Dr. Malini Jayaraj, M.D.S.,
Professor
Department of Oral &
Maxillofacial Surgery,
Ragas Dental College
Hospital, Chennai

RAGAS DENTAL COLLEGE & HOSPITAL
Dept. of Oral & Maxillofacial Surgery
Ph: 2453 0003 Ext - 17

Dr. M.Veerabahu, M.D.S, IBOMS.,
Professor and Head,
Department of Oral &
Maxillofacial Surgery,
Ragas Dental College &
Hospital, Chennai

Dr. M. VEERABAHU, MDS,IBOMS
Professor & HOD
Dept of OMFS
RAGAS DENTAL COLLEGE & HOSPITAL
Chennai - 600 119.

Dr. S. Ramachandran, M.D.S.,
Principal,
Ragas Dental College & Hospital, Chennai

PRINCIPAL
RAGAS DENTAL COLLEGE & HOSPITAL
CHENNAI

ACKNOWLEDGEMENT

First of all I wish to thank my loving dad ***Mr.V.Gunasekeran*** *for giving me a great foundation for my life and being with me in all circumstances as almighty.*

With deep satisfaction and immense pleasure, I present this work undertaken as a Post Graduate student specialising in Oral & Maxillofacial Surgery at Ragas Dental College and Hospital. I would like to acknowledge my working on this dissertation which has been a wonderful and enriching learning experience.

I am greatly indebted to ***Dr.M.Veerabahu, MDS.,*** *My professor and Head of the Department, Oral and Maxillofacial Surgery, Ragas Dental College and Hospital, Chennai, for his guidance and support. His constant guidance in the academic front as well as in surgical aspect during my studies has helped me a lot. I have been fortunate to study under his guidance and support. These memories definitely would cherish throughout my life.*

I would like to extend my heartfelt gratitude to professor ***Dr.S.Ramachandran****,* ***MDS.,*** *Principal, Ragas Dental College and Hospital, for allowing us to use the, scientific literature and research facilities of the college.*

I wish to convey my heartfelt thanks to my guide and Professor, ***Dr.Malini Jayaraj, MDS.,*** *a great teacher who has always been a source of* inspiration. I express my personal thanks to madam for being so tolerant, encouraging and understanding. I shall forever remain indebted to her for her valuable guidance and input throughout the making of this dissertation without which I would have never accomplished this particular research. It was an enriching experience to have spent three years of my life under her guidance.

I am greatly indebted to **Dr.Radhika Krishnan**, Anaesthesiologist, Ragas Dental College and Hospital, Chennai, for suggesting this topic and the protocol, persistent guidance and support in my dissertation and being helpful in completing this study in a desired shape.

I owe enormous debt of gratitude to my teacher **Prof. Dr.B.Vikraman**, for his unstinted guidance, moral support, encouragement and helping me in all ways for my curriculum and throughout my course.

I also express my sincere and profound thanks to **Prof. Dr.J.A.Nathan** for his guidance.

I sincerely thank my teachers **Dr. D. Shankar, Dr. J. Venkat Narayana**n, **Dr. T. Muthumani, Dr. Karthick, and Dr. Prabu** for their valuable guidance, encouragement and help during my Post graduation period.

I would also extend my gratitude to **Dr. Seema** and **Dr. Anusha** for their valuable suggestions and support.

I sincerely thank my colleagues ***Dr. D. Abhishek Johnson Babu, Dr. Brian. F. Pereira, Dr. Krishna Kumar M.G, Dr. Saravanan. B, Dr. Vimal. K*** *for their constant support, constructive criticism at every step and selfless co-operation during my course and being with me in all my ups and downs in my course. I would also like to thank my juniors* ***Dr. Abhishek. R. Balaji, Dr. A. Alphonse Christy Raja, Dr. N. Kingsen Blessy Issac, Dr. Ashish, Dr. Jay, Dr. Sindhu*** *for their encouragement and the timely help they have rendered during my course.*

I would sincerely thank my statistical analyser ***Dr. Shyam Sivasamy*** *for doing thqe analysis in my study. I would also thank Theatre assistant Mr.Venugopal and the staffs in minor and major OT for helping me throughout my post graduate period.*

It would be ungrateful if I don't thank my caring mother **Mrs. Malliga Gunasekeran** *, my loving sister* ***Ms. Saranya Gunasekeran****, my brother* ***Mr. Dhatchana Moorthy .G ,****my sis-in-law* ***Mrs. Samatha*** *and my friend and philosopher* ***Dr. M. Mohana Priya*** *for being a pillar in all my success and giving me a helping hand during my downfall in my entire life.*

I would like to dedicate this dissertation to my Loving dad ***Mr. V. Gunasekeran****, who always wanted me to reach great height in my life and see me in the position where I am today.*

CONTENTS

LIST OF TABLES

LIST OF GRAPHS

LIST OF FIGURES

ABSTRACT

PURPOSE:

The purpose of this study is assessment of blood loss in orthognathic surgery using nitroglycerine induced hypotensive anaesthesia and comparison of pre and postoperative haemoglobin, haematocrit and means arterial pressure.

MATERIALS AND METHOD:

10 young orthognathic patients were operated under hypotensive anaesthesia included in this study. Operations were Anterior maxillary osteotomies (n=6), Lefort I osteotomy (n=1), BSSRO (n=3), Sub apical osteotomy (n=1), Genioplasty (n=3). Pre and Post operative Haemogram, intra operative blood loss, duration of surgery were the studied parameters. Statistical analysis was performed using SPSS version 19.

RESULTS:

None of the patient required blood transfusion. Mean blood loss was 174.19ml with a range of 77.60 ml to maximum of 283 ml. Mean duration was 174 min with minimum of 75 min and maximum of 290 min. Mean preop Hb level was 12.14 gm%/dl and the mean postop Hb level was 10.14 gm%/dl. Mean preop Haemotocrit was 40.50% and postop Haemotocrit was 30.18%.

The mean arterial pressure was 72.86 mmHg with a minimum of 63.30 mmHg and maximum of 78.60 mmHg.

CONCLUSION:

Blood transfusion in orthognathic surgery could be prevented by induction of Nitroglycerine as hypotensive anaesthetic agent and reduces the length of surgery by improving the quality of surgical field.

KEYWORDS:

Nitroglycerine, induced hypotensive anaesthesia, blood loss, haemoglobin, haematocrit, Mean arterial pressure, Orthognathic surgery.

INTRODUCTION

Orthognathic surgery is well established for the correction of dentofacial deformities in terms of its outcome and safety, and bimaxillary osteotomies are frequently necessary to achieve an acceptable result. Due to the complex vascularity of the orofacial region, significant bleeding not readily controllable by conventional surgical techniques, especially when it involves intra bony capillaries are encountered resulting in the need for blood transfusion. Homologous blood transfusion is associated with a number of risks including transmission of bacterial, viral or protozoal infections and alloimmunization, and various strategies are available to minimize the likely need for such transfusion.

The orthognathic surgeries are Bilateral sagittal split ramus osteotomy, Subapical osteotomy, Genioplasty in Mandible. Lefort I osteotomy, Anterior maxillary osteotomy in Maxilla for the correction of various jaw deformities. However single-jaw and Bi-Jaw Procedure is performed separately in many patients.

Several authors like J.E Moening et al,[34] D.S. Precious et al,[39] Robert M. Dolman et al,[41] Nabil Samman et al[35] have done studies on effect of induced hypotensive anaesthesia in orthognathic surgery.

Deliberate hypotensive anaesthesia was first introduced by Gardner[24] who used arteriotomy to reduce arterial blood pressure during surgery in1946.

Since then, various techniques for inducing hypotension during surgery have been used in orthopaedic and neurosurgical procedures, and the technique was first used in oral and maxillofacial surgery by SCHABERG et al.[44] in 1976. Hypotensive anaesthesia has shown to reduce intraoperative blood loss in orthognathic surgeries.

Deliberate, controlled, hypotensive anaesthesia has been used during general surgical procedures in an attempt to reduce intraoperative haemorrhage and the resultant need for transfusion. In addition, it is claimed to improve the quality of the surgical field and reduce operative time.

Progress in anaesthesia has allowed more time for a surgeon to be fastidious about haemostasis, and new surgical techniques have improved the surgeon's ability to control bleeding. The controlled induction and maintenance of intraoperative controlled moderate hypotension (CMH) has become an important part of a major maxillofacial operation involving osteotomy of the mid face (Dolman et all, 2000).[41]

An arterial blood pressure 30% below a patient's usual MAP, with a minimum arterial pressure of 50 mmHg in American society of anaesthesiologists (ASA) I patients and a MAP not less than 80 mmHg in the elderly, is suggested as being clinically acceptable, as this does not impair perfusion of brain, heart, kidney and liver. Various pharmacological agents have been used for inducing hypotension during orthognathic surgery. Duration of CMH carries importance because prolonged hypoperfusion is not innocent and decrease of MAP below 70 mmHg might increase intraoperative blood loss due to vasodilatation.

Controlled hypotension rarely results in damage, however because organ blood flow is normally well maintained. Mortality due to controlled hypotension and consequent ischaemic organ failure was 0.02 – 0.06%. Current data indicate that MAP between 60 and 75 mmHg is safe for young healthy patients.

The two major benefits of CMH are reduction of blood loss and improvement in visibility of the surgical field. Reduction of blood loss eliminates the need for homologous blood transfusion, which has a potential risk of transmitting serious infections and causing haemolytic reactions. Estimated blood loss in orthognathic surgery with hypotensive anaesthesia has been reduced to 41 %.

CMH is contraindicated in presence of severe cardiac and respiratory diseases, our orthognathic patients are ASAPS I who are fit, young and healthy adults.

AIM AND OBJECTIVE

The purpose of this study is assessment of blood loss in orthognathic surgery using Nitroglycerine induced hypotensive anaesthesia and comparison of pre & post-operative Haematocrit, haemoglobin, MAP and RBC.

REVIEW OF LITERATURE

Control of haemorrhage and concept of hypotension began as early as 1917 by Harvey cushing and in 1946 James gardener adopted this concept into general anaesthesia.

Deliberate induction of hypotension in a controlled and safe manner with the mean arterial pressure maintained at 55-65 mmHg has been used in orthopaedic, pelvic, head and neck surgery and is valuable and effective in ENT, ophthalmic and neurosurgery.

Blood flow and organ perfusion is maintained by auto regulatory vaso-dilatation and hence this is a safe method in the range MAP of 60-70 mmHg.

Intra operative monitoring can be done by both Invasive and Non-invasive methods. In Non-invasive method of monitoring ECG, blood pressure, HR, PO_2 can be done using pulse oximeter. In invasive method EEG, Canography, HR, blood pressure, PO_2, PCO_2, body temperature can be calculated.

Invasive monitoring of blood pressure is more reliable and a sensitive indicator of cerebral perfusion, especially with the use of rapidly acting hypotensive agents like sodium nitroprusside, Trimetaphan are used or with wide fluctuation of blood pressure expected.

Capnography can be used to measure sudden changes in end expiratory PCO_2. It is used to avoid hyperventilation as decrease in PCO_2 decreases cerebral blood flow during hypotension.

Electroenchaphalography (EEG) is required to detect cortical hypoperfusion. Electrical activity becomes abnormal in cerebral blood flow at 20ml/minute.

Hypotensive drugs – Anaesthetic categories.

1. Ganglion blocking agents – Pentamethonium, Trimetaphan
2. Volatile anaesthetic agents – Isoflurane, Enflurane
3. Direct acting vasodilators – Nitroglycerine, Sodium nitroprusside, Calcium channel blockers, Beta-blockers, purine derivatives, Prostaglandin E.

EFFECTS OF HYPOTENSION ON ORGAN PERFUSION:

Central Nervous System:

- ✓ Perfusion Pressure = Arterial input pressure - Venous out flow Pressure (MAP-ICP)
- ✓ Minimum of 40 mmHg of perfusion pressure should be maintained essentially.
- ✓ Auto regulation is active till MAP 50-55 mmHg in normothermic patients.

Heart:

- ✓ Dead space and $PaCo_2$ increases when cardiac output is decreased.
- ✓ Nitroglycerine and Sodium Nitroprusside decreases Oxygenation.
- ✓ Controlled ventilation is preferred since it causes changes in oxygenation and eliminates CO_2.

Kidneys:

- ✓ Renal blood flow accounts 20-25% of cardiac output.
- ✓ Auto regulation is efficient.
- ✓ Recovery of urine production is efficient in Normovolemic patients.
- ✓ No need of strict monitoring in short surgeries is required.

Splanchnic circulation:

- ✓ During hypotension there is a change in liver perfusion because Pressure-flow auto regulation in absent in portal venous circulation.
- ✓ Auto regulation in intestine is less effective.
- ✓ It's very difficult to do clinical monitoring of splanchnic circulation.

Eye:

- ✓ With the decrease in arterial BP the intraocular pressure decreases.
- ✓ Blindness may rarely occur due to blurring of vision.

Skin and Muscle:

- ✓ Deliberate hypotension does not affects skin.
- ✓ When compared with nitroglycerine, sodium nitroprusside decreases Tissue oxygenation.

Bleeding during surgery depends on number of vessels cut, rate of flow from cut vessel and effectiveness of haemostasis. Rate of flow is the only controllable variable. It also depends on size of vessel and intraluminal pressure. Cardiac output or decreasing venous return can be able to control intraluminal pressure. The later is not preferred, as it will decrease tissue perfusion. Hence reducing venous return is the best option. **The principle of hypotensive anaesthesia is thus to induce low pressure, vasodilated circulation.**

Deliberate induction of hypotension during anaesthesia is an attempt to produce a controlled and safe reduction in intravascular pressure in hypotensive anaesthesia. The MAP is maintained at 60-70 mmHg during the surgery. **The principle of controlled hypotension is to induce a low pressure, vasodilated circulation.**

FUTURE OF CONTROLLED HYPOTENSIVE ANAESTHESIA:

Guyuron et al[21] evaluated and proved that Efficacy of hypotensive anaesthesia along with coagulant Desmopressin. No significant side effects of Desmopressin were reported.

In total hip surgeries **Ekback et al**[11] did a double-blinded study reporting 35% decrease in bleeding on administration of antifibrinolytic agent Tranxemic acid preoperatively.

A **Goran et al**[18] showed that blood loss during orthognathic surgeries under hypotensive anaesthesia (MAP<65mm Hg) could be significantly reduced when a combination of tranexamic acid and desmopressin is added. The mean blood loss was 740 ml in control group whereas it was 400 ml in treatment group.

W. James Gardner 1946[24] introduced arteriotomy. In this procedure blood was withdrawn from the patient preoperatively via the arterial route and then replaced in part by the same manner at the end of operation. This reduction in total circulating blood volume leads to lowering of blood pressure and peripheral vasoconstriction. Hence, decreased blood loss perioperatively.

Mc Neill TW et al 1974[36] et al did a retrospective study, comparing normotensive (22 patients) and hypotensive (44 patients) anaesthesia for spine fusion. The use of hypotensive anaesthesia was found to decrease the need for blood replacement and total blood loss by an average of 40% and to reduce the average operating time by more than 30 min. No complications attributable to anaesthetic technique occurred.

Schaberg et al 1976[44] has evaluated effect of sodium nitroprusside infusion supplemented with halothane in oro-facial corrective surgery. Various physiological parameters were measured pre operatively, intra operatively and post operatively to evaluate patient response to this anaesthetic method. The mean arterial pressure was reduced from 89.94 ±2.13 to 72.79 ± 1.63 mg under the influence of sodium nitroprusside. It is concluded from an extensive review of the literature that the most vulnerable period for serious complication is in the immediate postoperative period. No significant complications were observed in this study.

Kerr AR 1977[26] produced a blood-free field for middle ear surgery performed with the operating microscope; the arterial systolic pressure was reduced to less than 50 mm Hg in 700 patients by means of thiopentone-halothane-nitrous oxide in oxygen anaesthesia together with pentolinium tartrate. In 84% the results were excellent, in 12% moderately good and they were poor in 4%. There were more unsatisfactory results in males (22.8%) than in females (11.4%). In spite of the arterial pressure being reduced to low values in main instances, there was no mortality or morbidity, which could be ascribed to the technique.

Thompson GE et al 1978[49] attempted to determine effect of hypotensive anaesthesia on postoperative brain, liver, kidney and myocardium following total hip arthroplasty. MAP was decreased to 50 mmHg using high concentration of halothane or sodium nitroprusside. In the control group, MAP was maintained with 20% base line. Intraoperative blood loss decreased from 1,183 ±172ml normotensive to 406±102ml and 326 ± 41ml in halothane and nitroprusside hypotensive group respectively. Neither method affected the cerebral, hepatic or renal and myocardial function. There was no morbidity. Operating time was significantly reduced. Decreased blood loss lead to decrease in number of blood transfusions needed.

Gallagher DM et al 1979[16] reported that achieving satisfactory haemostasis during orthognathic surgery might be difficult because of the extensive vascularity of facial structures. Hypotensive anaesthetic techniques provide clear operative field by altering regional tissue perfusion through the use of systemic vasodilators, ganglionic blocking agents and positioning of the patient. Though monitoring during surgery, careful selection of patients, and close communication between the surgery and anaesthesiologist permit safe anaesthesia can decrease operating time, and usually obviate the need for transfusion.

Vandesteene et al 1980[52] have used sodium nitroprusside 0.01% solution to induce hypotensive state. Mean dose to maintain a mean blood pressure at about 50 mmHg was 1.37mcg/kg/min. The patients were operated for cerebral aneurysm or angioma. Adjuvant drugs and methods to reduce intracranial pressure such as dexamethasone, mannitol and cerebrospinal fluid substraction were used.

Sivarajan M et al 1980[46] emphasized that blood pressure and not cardiac output, determines blood loss during induced hypotension. Cardiac output characteristically decreases during trimethaphan Infusion but is well maintained or increased during sodium nitroprusside infusion. They postulated that at similar levels of mean arterial pressure, sodium nitroprusside might be associated with greater blood loss than trimethaphan due to the increase in cardiac output. They studied 20 young healthy patients scheduled for bilateral sagittal osteotomies of the mandible. Ten subjects received trimethaphan and 10 subjects received sodium nitroprusside. Using halothane (0.5 – 1%) & (60%) for maintenance of anaesthesia, trimethaphan or sodium nitroprusside was infused to maintain MAP between 55-60 mmHg; cardiac output was measured in five subjects in each group. Heart rate and cardiac output increased significantly and total peripheral resistance decreased significantly, during sodium nitroprusside infusion when compared to trimethaphan duration of hypotension or in blood loss. They include that operative blood loss during induced hypotension is determined by mean arterial pressure not cardiac output.

Chan W et al 1980[6] compared the blood loss, quality of operative field and he length of surgery in one type of orthognathic surgery – anterior maxillary osteotomy in normotensive and hypotensive anaesthesia. They found that by dropping a patients operative mean blood pressure below his mean blood pressure by 20% or more, the quality of the surgical field can be significantly improved (27%) and loss of blood can be decreased (41%).

Ward CF et al 1980[54] have described the effect of blood pressure reduction on organ perfusion, when deliberate reduction of blood pressure to reduce intraoperative blood loss was used.

Bergman S et al RF 1982[3] hypotensive anaesthesia is currently being used in oral and maxillofacial surgery to reduce blood loss and provide a relatively bloodless surgical field. Radioactively labelled microspheres were used to determine and compare the haemodynamic effects of sodium nitroprusside (SNP), nitroglycerin (NTG) and deep enflurane anaesthesia on oral tissues during controlled hypotension when compared with controls. Sodium nitroprusside and NTG produced significant reductions in blood flow to the maxilla, mandible and tongue, while deep enflurane anaesthesia did not. In the masseter and suprahyoid muscles, increases in tissue blood flow were found with SNP and enflurane. Nitroglycerine produced no significant change in blood flow in the masseter and suprahyoid. These results demonstrate that in spite of a similar cardiac index with all agents tested, local oral blood flow varied significantly with the different agents tested. These differences in tissue blood flow suggest that SNP and NTG may be preferable to deep enflurane anaesthesia for maxillary osteotomies to achieve greater flow reduction and diminish blood flow.

Fahmy S 1983[14] substituted enflurane for halothane to induce controlled hypotension, along with B-blockers and sympathetic ganglion blockers, in two groups. They constituted 1) Major maxillofacial surgery 2) Major neurosurgery. All patients were carefully monitored during anaesthesia and for24 hours post operatively. Good operative conditions were produced and no ill effects of controlled hypotension were detected in any of the patients.

Beierholm WE et al 1983[2] studied the haemodynamic effects of sodium nitroprusside in 6 patients undergoing surgery for intracranial aneurysm under controlled hypotension in endotracheal anaesthesia with halothane – nitrous oxide during hypocapnia mean arterial pressure was reduced with SNP from mean 12.25 Kpa to mean 8.29 Kpa [32%]. There were concomitant statistically significant heart rate, central venous pressure and pulmonary vascular resistance did not change significantly. After the infusion of SNP was discontinued all parameters except cardiac index and heart rate, return to values not significantly different from the control values. The hypotension induced by SNP resulted from reductions in cardiac index and systemic vascular resistance. The reduction in cardiac index did not reach a critical level in any of the patients.

Lam AM et al 1983[28] Deliberate hypotension induced with isoflurane in 13 patients, undergoing craniotomy for clipping of aneurysms. Cardiovascular functions and gas exchange were monitored before, during and after hypotension. In all cases, the desired level of hypotension [40+/- 1.0(SEM) mmHg] was achieved readily with prompt onset (5.7+/- 1.0 min) and recovery (6.3+/- 0.7 min). Cardiac output during hypotension (4.6+/- 0.3 L /min) was not significantly different from the control normotensive values (4.80 +/- 0.3 L / min). Gas tensions during hypotension and during normotension were PaO2 116+/- 6 and 111+/- 8 mmHg; respectively. No complication could be attribuited to the use of isoflurane. We conclude that isoflurane can be employed safely and effectively as a hypotensive agent in neurosurgery.

Golia JK et al 1985[17] has used nitroglycerine for controlled hypotension in orthognathic surgeries. Nitroglycerine (NTG) was chosen because of its beneficial cardiovascular effects and its lack of toxicity as compared with sodium nitroprusside 9 patients undergoing either maxillary or maxillary / mandibular osteotomies were anaesthetized with halothane, N_2O, O_2 and supplementary dose of muscle relaxants and narcotic. NTG was used to lower mean arterial pressure during periods of potential increased blood loss. Estimated blood loss was 439+/- 1.19ml. Haemoglobin and haematocrit fell slightly from 13.8+/-1.74gm/dl and 41.2+/-5.11% to 12.04 +/- 1.8gm/dl and 35.6+/- 4.9%. Alteration of the pulmonary hypoxic vasoconstriction reflex was also seen as was evidenced by a decrease in PaO2 after NTG administration. It was concluded that NTG is a safe and efficacious agent for controlled circulation during maxillary osteotomy surgery.

Guggiari M et al in 1985[20] the cardiovascular effects of nitroglycerine (NTG) were studied in 30 patients requiring controlled hypotension for intracranial aneurysm surgery. In patients “resistant” to NTG (n=9), sodium nitroprusside (SNP) was used to supplement the NTG. With NTG alone at a total dose of 31mg and mean hypotension duration of 28min, mean arterial pressure (MAP) decreased by 43%, from 78.3 to 44.4mm Hg as a result of decrease in cardiac index (CI) 18% and systemic vascular resistance(SVR) 21%. Simultaneously a moderate increase in (CaO2 – CvO2) 21% and a significant increase in plasma renin activity (90%) were observed. In patients "sensitive" to NTG, the MAP decreased by 54%, CI by 27% and SVR by 35%; HR remained stable. In patients resistant to NTG, the decreases in CI and SVR were less marked: 2% and 22% respectively; observed increase in HR was 12%. When nontoxic dosage of SNP were used (less than 2micrograms/kg/min), hypotension was caused by decreased SVR (31%) and increased CI (8%). NTG alone can be used to produce controlled decreases in MAP to around 50mm Hg, and in patients "resistant" to NTG, SNP can be added to increase the hypotensive effect.

Mac Rac WR 1985[31] the use of induced hypotension in the hands of a competent anaesthetist combined with the careful technique of a surgeon skilled in operating under these conditions can aid surgical access, improve delineation of pathology and reduce levels of blood loss, all of which are to the advantage of the patient. These advantages should encourage surgical and anaesthetic teams to become accomplished exponents of the art.

Gourdeau M et al 1986[19] oscillometry using an automatic monitor was compared with invasive blood pressure monitoring in 21 patients scheduled for surgery under general anaesthesia with deliberate hypotension. Six ranges of mean blood pressure measurements were studied, two of which were hypotensive. An excellent correlation was found between the two methods (systolic: r=0.94; mean: r=0.93; diastolic: r=0.88) but there was a large variability among individual subjects. For systolic, diastolic and mean intra-arterial readings above an approximate value of 10.64 KPa (80mmHg), the oscillatory monitor was found to underestimate blood pressure. Inversely, it was found to overestimate blood pressure for intra-arterial readings under the approximate value of 10.8 KPa (80mmHg). We conclude that the non-invasive monitor represents a good trend estimation of the invasive radial blood pressure technique, but that wide inter-individual variability and the overestimation of blood pressure below an approximate value of 10.64 KPa (80mmHg) precludes interchange of techniques when absolute values are considered, especially during controlled hypotension. However, oscillometry could represent a better estimate of central aortic pressure.

Pasch T et al 1986[37] over an eight year period (1977 – 1984), 1802 otorhinolaryngological procedures were performed under controlled hypotension. Four patients showed symptoms of cerebral damage post-operatively. One patient had pre-operative recognized stenosis of the internal carotid artery, another hypoplastic vertebral artery. In this female patient, the head had been strongly rotated to the side to expose the surgical field, and the internal jugular vein removed. She died of general ischaemic brain damage on the seventh post-operative day. In the remaining two patients, symptoms of cerebral ischaemia did not occur until the third and eleventh day, respectively, so that the causative role of hypotensive anaesthesia is uncertain. The cases described represent a cerebral morbidity of 4:1,802 (0.22%) and a mortality of 1:1,802 (0.06%). It is concluded that controlled hypotension is a safe technique if the induction is stringently applied, and any risk bearing factors are carefully excluded.

Campkin TV et al 1986[5] the used isoflurane to induce arterial pressure (MAP) to the desired level for surgery; for the remainder, a higher concentration (3.0-4.0%) was required. Tachycardia, which could be slowed by labetalol, occurred in13 patients (32%); the incidence was significantly higher in those who had not received an opiod either as premedication or intra-operatively. No post-operative complications attributable to hypotension were seen. It is concluded that isoflurane is a safe and effective agent for the induction of hypotension in neurosurgical operations.

Myron Yaster MD et al 1986[33] compared nitroglycerine and nitroprusside for inducing hypotension in children by conducting a double blind study. NTG is doses as high as 40 $mg/kg^{-1}min^{-1}$ was in effective at decreasing mean arterial pressure below 55mm Hg or causing a decrease in MAP greater than 1/3rd of base line values. SNP was uniformly successful at inducing hypotension in all patients; including those patients in than NTG failed. NTG & SNP decreased systemic vascular resistance, although SNP did so to a much greater degree. Both drug reflexly increased heart rate, necessitating the use of propanol, and decreased arterial oxygen tension to a small extent. SNP appears to be the agent of choice for the reliable and sustained induction of deliberate hypotension in children and adolescents.

Sollevi A 1988[47] Controlled hypotension reduces blood loss during defined major surgical procedures, which in turn will minimize transfusion needs and thereby the risks of transmission of infectious diseases. There is no evidence that hypotension below 8 kPa (60 mmHg) (MAP) is associated with better blood sparing effects that a more moderate hypotension, but it will probably increase the risk of cardiovascular complications. Therefore, controlled hypotension, being a sophisticated technique, requires handling by an experienced anaesthetist well aware of contraindications and the need for adequate monitoring for prevention of tissue ischemia. Large randomized and prospective studies are still warranted, especially for further evaluation of the risk-benefit with controlled hypotension.

Lessard MR et al 1989[30] studies the effect of isoflurane induced hypotension on reduction of blood loss, improvement of surgical field, and postoperative oedema in 52 patients undergoing combined maxillary and mandibular osteotomies. Blood loss in the hypotensive group (MAP – 55 to 65 mmHg) was significantly less than that in the control group (MAP – 75to 85 mm Hg); 454 +/- 211.3 ml Vs 755.3 +/- 334.6 ml (fewer patients had to be transfused in the hypotensive group 12% Vs 44%). The surgical field improved significantly, but operative time was not shortened. Subjective and objective measurements of postoperative oedema failed to show any effect of deliberate hypotension. They concluded that enflurane-induced hypotension effectively reduces blood loss and the number of transfusion in orthognathic surgery.

J. E. Moening et al 1995[34] did a retrospective study comparing 506 patients who underwent orthognathic surgery both single and double jaw. Average estimated blood loss for all groups was 273.23 ml. Double jaw surgery resulted in more blood loss than single jaw procedure. Men and boys bleed more than women and girls. Only 0.8% received blood transfusion. They concluded that for reducing blood loss are hypotensive anaesthesia, single surgical team and constant surgical setting.

Precious DS et al 1996[39] had compared blood loss, quality of surgical field, and duration of procedure in normotensive and hypotensive anaesthesia in adolescent orthognathic surgery patients. Sample size was 25 in each group. Results showed significant decrease in blood loss, better surgical field with no significant difference in duration of the procedure with induced hypotensive anaesthesia.

Nabil Samman et al 1996[35] quantified the blood loss & transfusion requirements in orthognathic surgery by a retrospective study, comprising 360 healthy orthognathic surgery patients. Estimated blood loss ranged from 50 to 5000 ml, 24% were transfused. 8.7% - single jaw surgery and iliac bone harvest 26.7% after bimaxillary surgery.

Guyron B et al 1996[21] Desmopressin (1 – deamino-8-D-argininevasopressin, DDAVP) is a synthetic analog of the antidiuretic hormone L – argininevasopressin. DDVAP has been shown to increase the plasma concentration of endothelial factor VIII, thus increasing coagulant activity. There is evidence from controlled clinical trials indicating that DDVAP can reduce blood loss and transfusion requirements for individuals with normal coagulation profiles undergoing various surgical procedures. This study was conducted to evaluate the efficacy of the DDVAP in reduction of blood loss during orthognathic surgery. 20 patients, 15 females and 5 males, undergoing bimaxillary osteotomy were randomized into two groups of ten. Perioperatively, group 1 patients received 20 micrograms of DDVAP infused over one-half hour. Group II patients did not receive DDVAP. Hypotensive anaesthesia (mean arterial pressure < 60 mmHg) was routinely employed for both groups. On average, the blood loss in group 1 patients was 144 ml less per patient than group II patients ($p < 0.50$). Only 2 of 10 patients in group 1 lost in excess of 750 ml ($p < 0.20$). The average postoperative haematocrit for patients in group 1 dropped by 6.17 of the preoperative mean haematocrit ($p < 0.001$). The average drop in haematocrit among the group II patients was 11.61 ($p < 0.001$). When collated this haematocrit drop of 11.61 for group II and 6.17 for group I (recipients of DDVAP) proved to be significantly different ($p < 0.01$). It is concluded from this study that patients receiving a standard dose of DDVAP prior to bimaxillary osteotomy would experience reduced intraoperative blood loss, providing that blood pressure is well controlled and fluid replacement is carefully managed. No significant adverse side effects of desmopressin acetate were observed.

Van de Perre JP et al 1996[51] the data of 2049 patients, who underwent maxillofacial orthopaedic surgery, were retrospectively analysed for major intra- and immediate postoperative complications. Immediate life-threatening complications were very rare. They can in most cases be avoided by good anaesthetic and surgical techniques and adequate postoperative care. The most frequently encountered problem in maxillary surgery is excessive blood loss, whilst a compromised airway due to swelling is the most frequent complication in mandibular surgery. Good co-operation between anaesthetist and surgeon is essential to prevent major intraoperative and immediate postoperative problems.

Enlund MG et al 1997[12] the need for induced hypotension in orthognathic surgery was evaluated. Blood loss, duration of operation, quality of the surgical field, and surgical result were measured in 36 patients, assigned to either hypotension (mean arterial pressure, MAP, 50-64 mmHg) or normotension (MAP > or = 65 mmHg). Hypotension was achieved by increasing the amount of isoflurane given. The hypotensive group had significantly less bleeding over time (mean 0.9 ml/minute, 95% confidence interval (Cl) of mean 0.6 to 1.2, compared with 1.8, 95% Cl 1.3 to 2.4, p = 0.005). The corresponding difference in total blood loss did not differ significantly between groups (mean 186 ml, 95% Cl 98 to 275, compared with

304ml, 95% Cl 210 to 399). No patient required transfusion of red cells. Neither the duration of surgery, nor the quality of the surgical field, or the final results were significantly influenced by hypotension. The clinical relevance of induced in orthognathic surgery must be considered to be doubtful. A mean reduction of less than 150 ml will be of limited value at the low levels of blood loss reported.

R.G. Rohling et al 1999[42] have described a protocol of blood-saving measures, which was rested on a sample of 127 patients treated between 1994 & 1997. The protocol comprises acute normovolemic haemodilution, controlled moderate hypotension, positioning the surgical field above the heart level, cell saving, intra operative homeostasis, preoperative autologous blood donation, administration of recombinant erythropoietin, and acceptance of low haematocrit perioperatively. This study showed that homologous blood transfusion might be awarded intra operatively by following the protocol.

CNF Yu et al 2000[7] in their prospective study including 32 patients undergoing orthognathic surgery under induced hypotensive anaesthesia found that mean estimated blood loss for double jaw surgery was 617.6ml mean EBL during Lefort I was half that of multiple segmentalised osteotomies for mandibular ramus osteotomies, mean BBL and operating times was 280 ml and 2 hours respectively, for anterior mandibular osteotomies the corresponding values were 171.3 ml and 1 hour 13 minutes. Average drop in haematocrit value was 15.4%. A bivariate correlation test between the blood loss and operating time are a strong correlation ($p<0.01$) as did blood loss with a drop in haematocrit value ($p<0.01$). Orthognathic surgeries are thus safe and predictable in terms of intra operative blood loss and operating time.

Ekback G et al 2000[11] Intraoperatively administered, tranexamic acid (TA) does not reduce bleeding in total hip replacement (THR). Therefore, its prophylactic use was attempted in the present study because this has been shown to be more effective in cardiac surgery. We investigated 40 patients undergoing THR in a prospective, randomized, double-blinded study. Twenty patients received TA given in two bolus doses of 10 mg/kg each, the first just before surgical incision and the second 3 h later. In addition, a continuous infusion of TA, 1.0 mg. kg (-1) for 10 h, was given after the first bolus dose. The remaining 20 patients formed a control group. Both groups used preoperative autologous blood donation and intraoperative autotransfusion. Intraoperative bleeding was significantly less (P = 0.001) in the TA group compared with the control group (630 +/- 220 mL vs 850 +/- 260 mL). Postoperative drainage bleeding was correspondingly less (P = 0.001) (520 +/- 280 vs 920 +/- 410 mL). Up to 10 h postoperatively, plasma D-dimer concentration was halved in the TA group compared with the control group. One patient in each group had an ultrasound-verified late deep vein thrombosis. In conclusion, we found TA, administered before surgical incision, to be efficient in reducing bleeding during THR. Implications: In a prospective, double-blinded study of 40 patients undergoing total hip replacement, the preoperative administration of tranexamic acid reduced bleeding by 35%, probably by decreasing induced fibrinolysis. Whether tranexamic acid therapy can replace predonation of autologous blood or intraoperative autotransfusion requires further study.

Dolman RM et al 2000[41] conducted a prospective study to compare the quality of the surgical field, blood loss, and operating time with either hypotensive or normotensive anaesthesia during Lefort I osteotomies. 23 patients were randomised into normotensive or hypotensive anaesthesia groups. The quality of the surgical field was assessed intra operatively by direct observation and again postoperatively by video imaging. There was a statistically significant correlation ($p < .0001$) between the surgeon's perception of the quality of the surgical field and the blood pressure. There was also statistically significant reduction ($p < .01$) in blood loss when using hypotensive anaesthesia and there was no statistically significant reduction ($p = 0.44$) in operating time when using hypotensive anaesthesia.

Praveen K et al 2001[38] conducted a randomized study to find out whether hypotensive anaesthesia minimized blood loss during orthognathic surgery. 53 consecutive patients, 15-33 years old were randomly allocated to either normotensive or hypotensive anaesthesia. Patients under hypotensive anaesthesia showed a Median (range) blood loss/operation (ml) was 200 (90-400) ml and under normotensive anaesthesia were 350ml (130- 1575) ($p = 0.01$), and those for maxillary segmental osteotomy under hypotensive anaesthesia were 85 (40-240) ml and under normotensive anaesthesia were 175 (100-190) ml (p = 0.05). Result showed that there was pronounced reduction in blood loss during orthognathic surgery done under hypotensive anaesthesia.

Stewart A et al 2001[48] have done randomized, placebo controlled, double blind trial (each 15), giving Apotronin intravenously (200ml) before the operation and then 50 ml per hour until the end of the operation during simultaneous Lefort I and mandibular sagittal split osteotomies, lost 52% less blood than control. EBL in apotronin group was 473 ml compared with 986 ml in controls. Blood was transfused in 1 patient in apotronin group compared to 9 in control group. No complications due to drug encountered.

Goran Zellin et al 2004[18] determined whether the addition of haemorrhage depressors to other medication during orthognathic surgery would further reduce the blood loss. Thirty patients undergoing Lefort I osteotomy were studied, one group was operated under hypotension anaesthesia, the other under received additional haemorrhage depressors, tranexamic acid and desmopressin. The results showed statistically significant reduction of blood loss in the treatment group (P < 0.01). They concluded that blood loss during orthognathic surgery under hypotensive anaesthesia could be significantly reduced when a combination of tanexamic acid and desmopressin is added.

D. K. Dhariwal et al 2004[8] reviewed the records of 115 consecutive cases of simultaneous bimaxillary osteotomies at Morriston Hospital over a 5 year period and they concluded that for patients requiring bimaxillary orthognathic surgery, it was important to evaluate each patient for their cross-matching requirements.

Emeka Nkenke et al 2005[13] did a clinical study to assess the reduction of the haemoglobin value and the frequency of blood transfusions during bimaxillary orthognathic surgery in 56 patients and concluded that the haemoglobin value reduced postoperatively by 2.6 +/- 1.4 g/100ml in the non-donors and by 2.6 +/- 1.1 g/100ml in the donors need blood transfusion

Koichiro Ueki et al 2005[27] did a study in 62 prognathic patients to predict the need for blood transfusion during orthognathic surgery and he concluded that the transfusion was not necessary in IVRO (intra oral vertical ramus Osteotomy) or SSRO (sagittal split Osteotomy) with or without Le Fort I Osteotomy.

Peter Kessler et al 2006 did a study to determine the frequency of blood transfusion and to evaluate the need for autogenous blood donations in patients undergoing bimaxillary orthognathic surgery and concluded that the preoperative autogenous blood transfusion appears to be effective in reducing exposure to allogenic blood.

W.S. Choi et al 2008[4] did a systematic review to investigate the evidence of the risks like increased heart rate, decrease in systemic vascular resistance, decrease in arterial oxygen tension, reduced urine flow which can be reversed to normal and benefits like decreased blood loss, increased surgical visibility, decrease surgical time. Finally author concluded although there are certain risks associated with hypotensive anaesthesia, most orthognathic patients are young and fit and complications are rare which can be avoided by thorough preoperative assessment and appropriate continuous monitoring.

Yoshikawa. F et al 2009[54] conducted a study to determine the difference in endocrine response, blood loss and arterial blood gas profiles between patients subjected to hypotensive anaesthesia or normotensive anaesthesia in 36 patients and concluded that blood loss was smaller and duration of surgery was shorter in hypotensive anaesthesia group and no significant differences in hormone levels in either group

Alissa Lockwood et al 2010[1] did a critical review of the evidence and clinical relevance to confirm the associated cyanide toxicity in adult patients with sodium nitroprusside and concluded that SNP is still a reasonable agent to use in the management of patients with hypertension today and can safely be used beyond doses of 2 µg/kg/min. Furthermore, in lieu of CN levels, monitoring of lactic acid levels is also reasonable measure to ensure safety.

J.Ervens et al 2010[10] did a prospective, single blinded, randomized controlled clinical study to compare the effect of induced hypotensive anaesthesia vs isovolaemic hemodilution on blood loss and transfusion requirements in orthognathic surgery and concluded that the hypotensive anaesthesia significantly reduces blood loss and transfusion risks whereas induced hypotensive anaesthesia combined with isovolaemic hemodilution has no addition blood sparing effects but impairs surgical field quality. International journal of oral and maxillofacial surgery in 2010.

Varol .A et al 2010[53] conducted a study to evaluate the role of induced hypotension during maxillary downfracture osteotomy on the requirement for blood transfusion, duration of operation in bimaxillary surgery in 45 young patients. Concluded that none of the patients received a blood transfusion and transfusion in bimaxillary orthognathic surgery could be prevented by induction of hypotension during maxillary downfracture.

MATERIALS AND METHODS

Patients:

This study is conducted at department of Oral and Maxillofacial Surgery, Ragas Dental College and Hospital, Chennai. A total of 10 cases (5 males and 5 females, the mean age was 22.9 years, with an age range of 18-27 years) undergoing Orthognathic Surgery were included in this clinical study. These patients underwent Orthognathic Surgeries from July 2011 to October 2012. Informed Consent was obtained from the Patient, Parents/Guardian and Institutional Ethical Committee.

Data included age, sex, patient's complaint, relevant medical history and dental history, clinical findings, blood investigations, radiographic findings, cephalometric findings including Preoperative and Postoperative blood loss during surgery and the duration of surgery was calculated.

All patients were fit, young and healthy adults (ASAPS 1). General examination was carried on and medical status was evaluated. All patients denied usage of any medication within the 2 weeks prior to surgery. None of the patients had known connective tissue disorder, Cardiovascular, renal, respiratory and hepatic disorder, h/o haemostatic disorder or diasthesis were excluded. Diagnosis was made from clinical, radiographic and cephalometric findings.

Treatment was planned giving patient's concerns prime importance, surgeries included Anterior Maxillary osteotomies (n=6), Lefort 1 osteotomies (n=1), BSSRO (n=3), Subapical Osteotomies (n=1), Genioplasty (n=3) .Patients were given Hypotension Anaesthesia intra-operatively. Pre-operatively Blood Pressure, Pulse rate, Haemoglobin and Hematocrit was calculated, duration of the surgery was calculated.

Method:

Patient Preparation:

Patients were prepared the day prior to the procedure, 2ml of blood withdrawn from Brachial Vein and cross matching done in VHS blood bank, one unit of whole blood booked for the surgery. All patients were Nil-by-mouth from 6 hours prior to the surgery.

Pre-Medication:

Pre-medication comprised Inj. Fortwyn 0.6 mg/kg, Inj. Phenergan 0.5 mg/kg, Inj. Glycopyrolate 0.04 mg/kg, which was given intra-muscular 30 min prior to surgery.

Induction anaesthesia was induced by Inj. Thiopentone 5mg/kg and Inj. Succinyl Choline 1-2 mg/kg Intra-venously. Patients were intubated by cuffed nasoendotracheal tube. Anaesthesia was maintained by N_2O and O_2 (60:40 ratio) and long acting muscle relaxants Inj. Vercuronium bromide 0.08 mg/kg. Throat pack was placed using ribbon gauge of standard length.

Local anaesthesia was given using 2% lignocaine with 1:2,00,000 adrenaline. Before making incision in all cases head end was elevated. Electrocautery was used in all surgeries for incision. Patients were given Nitroglycerine (3-10 mcg/kg/min) as induced hypotensive anaesthesia diluted in DNS or 5% Dextrose before the osteotomy cut was performed. Mean arterial pressure was maintained around 70 mm/Hg till the osteotomy fragments were fixed. Inj. Taxim 1gm, Inj. Metrogyl 500mg, Inj. Decadron 8mg, Inj. Rantac 50mg , Inj. Emeset 4 mg given IV during the surgery and Inj Voveron 3cc given IM post operatively, nitroglycerine was slowly reduced as Mean arterial pressure slowly raised .Anaesthesia was withdrawn by giving reversal using Inj. Neostigmine+Glycopyrolate 0.05-0.07 mg/kg. Haemostasis was checked. None of the patients were placed with haemostatic agent like surgical or bone wax.

Intra-operative monitoring comprised Electrocardiography, Blood pressure, Pulse oximetry and Heart rate. Continuous monitoring of Blood pressure was done by non-invasive method (oscillometry). (MAP = diastolic pressure+1/3 of pulse pressure).

Anaesthesia duration time was calculated from induction to reversal and surgery duration from incision to last suture.

A single observer measured blood loss after every surgery. It was measured by reducing the amount of saline used, from the volume of fluid in suction unit, weight of dry gauze was deducted from weight of the blood soaked gauze. 1 gm of weight was considered 1 ml of blood. The need to transfuse blood post operatively was decided by the Anaesthetist.

Statistical procedures

The data obtained was tabulated meaningfully in Microsoft Excel spread sheet and subjected to statistical analysis. Data analysis was carried out using SPSS version 19. Data related to Arterial pressure, Blood loss and Duration of surgery was expressed in terms of descriptive statistics. Comparison between the means of Haemoglobin%, Haematocrit% and RBC% among study subjects before and after surgery was done using Paired t test. For all the analysis p value of < 0.05 was considered to be statistically significant.

Estimation of Estimated Blood Volume (EBV) and Allowable Blood Loss (ABL):

ESTIMATED BLOOD VOLUME:

- Neonates – 85 -90 ml/kg body weight
- Children – 80 ml/kg body weight
- Adults – 70 ml/kg body weight

ALLOWABLE BLOOD LOSS:

METHOD	**HEALTHY**	**AVERAGE CLINICAL CONDITION**	**POOR CLINICAL CONDITION**
PERCENTAGE METHOD (ACCEPTABLE LOSS OF BLOOD VOLUME)	**30%**	**20%**	**LESS THAN 10%**

$$ABL = \frac{\text{EBV x (PREOPERATIVE Hb – LOWEST ACCEPTABLE Hb)}}{\text{(AVERAGE OF PREOPERATIVE \& LOWEST ACCEPTABLE Hb)}}$$

Data collection:

Gauze of standard size was used. Weight of the gauze was determined before sterilizing. Volume of the saline used for irrigation was recorded. Volume of fluid (saline + blood) in suction was noted. Weight of the blood soaked gauze was determined. These data were collected using Gravimetric and Volumetric method.

BLOOD LOSS = (A+B)

A = Volume in suction – Volume of saline used

B = Weight of wet gauze – Weight of dry gauze

PROFORMA

MEASURMENT OF BLOOD LOSS – IN SURGICAL PROCEDURE

NAME: **OP NO:**

AGE:

SEX:

WEIGHT:

PAST MEDICAL HISTORY

RESPIRATORY:

CVS:

RENAL:

HEPATIC:

DIAGNOSIS:

SURGERY PLANNED:

DATE OF SURGERY:

PREMEDICATION:

	Pre-operative	Post-operative
Blood Pressure		
Hb%		
Hct		

INTRA OPERATIVE MONITERING

Time	BP Systolic	BP Diastolic	Mean	Heart rate	PO_2%

ANAESTHESIA: START- FINISH-

SURGERY : START- FINISH-

BLOOD LOSS:

VOLUME OF SALINE USED INTRA OPERATIVELY	
VOLUME OF FLUID IN SUCTION APPARATUS	
WEIGHT OF GAUZE SOAKED IN BLOOD	
WEIGHT OF DRY GAUZE	
TOTAL BLOOD LOSS	

Fig 1 : PULSEOXIMETER

Fig 2 : NITROGLYCERINE DILUTED IN DNS

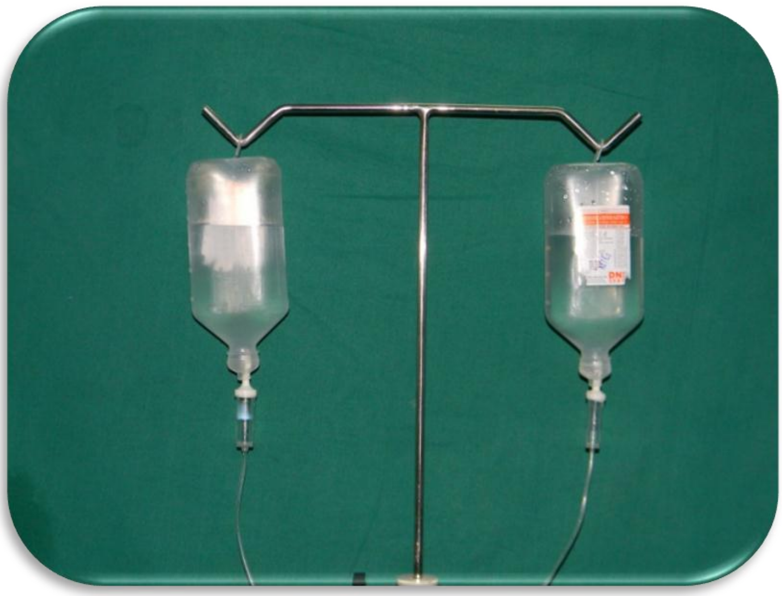


Fig 3 : WEIGHING MACHINE WITH BLOOD SOAKED GAUZE

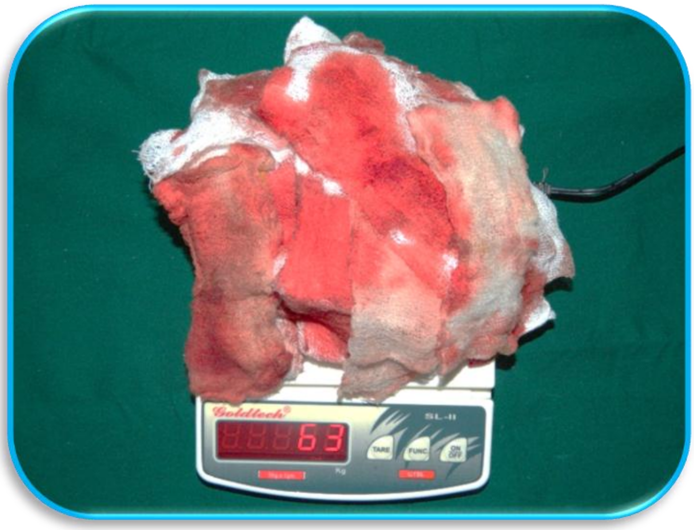


Fig 4: SUCTION DRAIN

HISTORY

Controlled moderate hypotensive anaesthesia is beneficial in providing a clear surgical field and avoids the necessity of blood transfusion and its inherent risks.

Anaesthesia became easy and satisfactory for the anaesthetist when cyclopropane was used, but it was a troublesome for the surgeon due to excess bleeding. The side effect of cyclopropane was skin showing marked vasodilatation.

Deliberate hypotension was first proposed by Harvey Cushing in 1917 for neurosurgery. Induced hypotension was first given by Gardener[24] in 1946 as a separate anaesthetic procedure.

In 1948, Griffiths and Gillies reported high spinal anaesthesia, blocking sympathetic fibres, which induced vasodilatation below the level of block and produced profound hypotension.

Enderby used Pentamethonium iodine as the first hypotensive agent to reduce blood loss. Magill in 1953 successfully used short acting ganglion blocker trimethaphan, which had better control over blood pressure. Other ganglionic blockers that followed soon were hexamethonium, pentolinium, guanethidine.

Lessard in 1989 had used isoflurane successfully in combined jaw surgeries.[30] PG E1, adenosine, calcium channel blockers are recently introduced hypotensive agents.

Schaberg[44] has evaluated effects on sodium nitroprusside infusion supplemented with halothane in oral- facial corrective surgery.

Kerr[26] produced a blood free field for middle ear surgery done with an operating microscope by means of thiopentone – halothane-nitrous oxide together with pentolinium tartrate. Sivarajan[46] used trimethaphan infusion which decreased cardiac output characteristically.

Bergman[3] in 1982 was the first to used enflurane, sodium nitroprusside (SNP) and nitroglycerine (NTG) on oral tissues and determined NTG and SNP produced significant reduction in blood flow. Golia and Guggiari used nitroglycerine for controlled hypotension in orthognathic surgery.[17,20] Yaster M[33] in 1986 did a comparative study on nitroglycerine and nitroprusside.

Fahmy[14] substituted enflurane for halothane to induce controlled hypotension, along with B-blockers and sympathetic ganglionic blockers. Lam[28] used isoflurane to induce deliberate hypotension in 1983.

Campkin used isoflurane to induce arterial pressure (MAP) to the desired level for surgery.[5] Guyron[21] used Desmopressin a synthetic analog of the antidiuretic hormone L-argininevasopressin for reducing blood loss and transfusion.

Ekback[11] reported intraoperative administration of tranexamic acid (TA) doesnot reduce bleeding in total hip surgery. Samman[4] in 2008 did a study in risk and benefits of deliberate hypotension using nitroglycerine. Praveen K et al[38] in 2001 used nitroglycerin and esmolal as hypotensive agent in orthognathic surgery.

PHARMACOKINETICS AND PHARMACODYNAMICS

NITROGLYCERINE:

The drug has been used for years to treat patients coronary artery spasm or with myocardial infractions and to control periods of hypertension in-patients with known coronary artery disease. Chemical name of nitroglycerine is 1,2,3 propanetriol nitrate. The chemical structure of nitroglycerine is,

$H_2C – O – NO_2$

$HC – O – NO_2$

Properties:

Nitroglycerine is basically a vascular smooth, muscular relaxant. It dilates both arterial and venous beds; however, it has preferential effect on the post capillary vessels, including large veins to which it promotes peripheral pooling of blood and decreasing venous return to the heart leading to the reduction to left ventricular and diastolic volume (pre-load). Arterial relaxation produced by nitroglycerine leads to reduction in systematic vascular resistance and arterial pressure (after-load). These effects of nitroglycerine produce reduction in the myocardial oxygen consumption or demand and thus a more favourable supply – demand and thus a more favourable supply – demand ratio is achieved. The recommended doses of intra venous nitroglycerine reduce systolic, diastolic and mean arterial pressure while maintaining effective coronary perfusion pressure, unless there is an excessive pain in blood pressure.

Intra venous nitroglycerine therapy reduces elevated central venous and pulmonory capillary wedge pressures, pulmonary vascular resistance and systemic vascular resistance. Heart rate is usually slightly increased, as a part of the reflex response to the fall in blood pressure. Cardiac index may be increased, decreased or unchanged. In the presence of elevated left ventricular filling pressure and systemic vascular resistance along with the depressed cardiac index there is a likelihood of an improvement in cardiac index. On the other hand, when filling pressures and cardiac index is normal, cardiac index may be slightly reduced by intra venous nitroglycerine therapy.

PHARMACOKINETICS:

Nitroglycrine is widely distributed in the body and is rapidly metabolized to dinitrates and mononitrates. It has a short half-life, estimated of 2 -8 minutes. This make it possible to monitor and control the plasma levels of nitroglycerine during intra venous infusion.

Nitroglycerine is readily absorbed into the plastic materials parenteral solution containers and tubings of intra venous infusion sets. Therefore, the dilution and storage of nitroglycerine for intra venous infusion should be made only in glass parenteral solution bottles.

Forty percent to eighty percent of the total amount of nitroglycerine in the final diluted solution for infusion is absorbed by the polyvinyl chloride (PVC) tubing of the intra venous administration sets. The rate of absorption depends upon the flow rate, nitroglycerine concentration and the length of the tubing etc…

INDICATIONS:

1. Angina pectoris, including unstable angina pectoris and post-infraction angina pectoris in patients who have responded to recommended doses of organic nitrates and or beta blockers.
2. Acute myocardial infraction, congestion heart failure and improvement of coronary circulation opening of collaterals and reduction of infract size.
3. Control of blood pressure in perioperative hypertension i.e., hypertension associated with surgical procedures, especially cardiovascular procedures, such as hypertension seen during intratracheal intubation, anaesthesia; skin incision, osteotomy, cardiac bypass and in the immediate postsurgical period.
4. Production of controlled hypotension during orthognathic procedures.

CONTRAINDICATIONS:

1. Known hypersensitivity to nitroglycerine or other organic nitrates.
2. Hypotension or uncovered hypovolaemia as the use of nitroglycerine injection in such conditions could produce severe hypotension or shock.
3. Increased intracranial pressure (eg: head trauma or cerebral haemorrage).
4. Inadequate cerebral circulation, constrictive pericarditis and cardiac tamponade.

PRECAUTIONS:

1. Nitroglycerine injection should be used with caution in patients with severe hepatic or renal disease.
2. Excessive fall in blood pressure, especially for prolonged periods of time, must be avoided because of possible deleterious effects on the brain, heart, liver and kidney from poor perfusion and the attendant risks of ischemia, thrombosis and altered functions of these organs. Patients with normal or low pulmonary capillary wedge pressure are especially sensitive to the hypotensive effects of nitroglycerine injection. It is advisable to monitor the pulmonary capillary wedge

pressure to titrate the dosage of the drug and as it generally proceeds the occurrence of arterial hypotension.

3. Use during pregnancy: The safety of the use of nitroglycerine injection during pregnancy has not been established; therefore it should be given to pregnant women only if clearly needed.

ADVERSE EFFECTS:

The commonly observed adverse effects of nitroglycerine injection are extensions of its pharmacological actions, which include headache, flushing, dizziness. Nausea, vomiting and abdominal pain have also been reported. Paradoxical bradycardia and increased angina pectoris may accompany nitroglycerine induced hypotension.

DOSAGE AND ADMINISTRATION:

Nitroglycerine injection is a concentrated, potent drug, which must be diluted in 5% dextrose or normal saline prior to infusion. It should not be admixed with other drugs.

The administration of nitroglycerine infusion is initially begin with 5 microgram per minute with subsequent titration to adjust that dose in accordance with the clinical situations with increments of 5 microgram per minute, every 3 to 5 minutes until some response is noted. If no response is seen at 20 microgram per minute, increments of 10 and later 20 microgram per minute can be used. Once a partial blood pressure response is observed, the dose increase should be reduced and the interval between increments should be lengthened.

RESULTS

The study was conducted in 10 young healthy individual undergoing orthognathic procedures. The male: female ratio was 1:1 (five males and five females), with an age range of 18 – 27 years (mean – 22.9 years). All 10 patients were subjected to Hypotensive anaesthesia. The Mean Arterial Pressure (MAP) ranges from 63.30 mmHg – 78.60 mmHg (Mean – 72.86 mmHg).

DURATION OF SURGERY:

The total operating time consists of time taken from start of surgery, administration of Local anaesthesia, extraction of tooth, mucoperiosteal incision, osteotomy cut and downfracture, control of bleeding, fixation and closure of last suture. The operating time for maxillary single jaw surgery ranges from 100 – 160 min (Mean – 65.20 min), mandibular single Jaw surgery ranges from 75 – 270 min (Mean – 160 min), Bi-jaw surgery ranges from 140 – 290 min (Mean – 236.6 min). The total operating time in this study ranges from 75 – 290 min (Mean – 174 min).

BLOOD LOSS:

The amount of blood loss was calculated by reducing the amount of suction collection with the amount of saline used for irrigation and by weighing the already weighed blood soaked gauze and throat pack. Each gram increase in wet gauze will denote I ml blood. By adding these two variables total blood loss was calculated in this study. Blood loss in maxillary single jaw surgery was 158.4 min – 174.2ml (mean – 169.6 ml), mandibular single jaw procedure was 77.60 ml – 169.6 ml (mean – 117.7 ml) and in bi-jaw procedure was 200 ml – 283 ml (mean – 236.76 ml). The total blood loss ranges from 77.60 ml – 283 ml (mean – 174.19 ml). There was a minimal amount of blood loss noted.

Preoperative/Postoperative Hg, Hct and RBC levels:

Pre and Post-op Haemoglobin, Haematocrit and RBC values were calculated. The mean Haemoglobin% pre and post-operatively was 12.14 % and 10.04% respectively. The mean Haematocrit% pre and post-op was 40.50% and 33.20% and the mean RBC% value pre and post-op was 36.42% and 30.18%.

DEMOGRAPHIC DATA 1: SHOWING PATIENTS AGE, SEX, WEIGHT & PER OPERATIVE MEAN ARTERIAL PRESSURE

VARIABLES	VALUES
Sex: Male Female	5 5
Age (years)	22.9
MAP Preoperatively (mm Hg)	90.97
Weight (Kgs)	54.1

DEMOGRAPHIC DATA 2: SHOWING PATIENTS PRE AND POST OPERATIVE HAEMOGLOBIN, HAEMATOCRIT, RBC

Pt.no	Haemoglobin %		Haematocrit%		RBC%	
	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
1	13.5	12.9	45	43	40.5	38.7
2	9.0	6.7	30	22	27	20.1
3	13.2	9.4	44	31	39.6	28.2
4	11.8	10.4	40	34	35.4	31.2
5	13.6	11.2	45	37	40.8	33.6
6	12.9	9.8	43	32	38.7	29.4
7	10.3	8.1	34	27	30.9	24.3
8	11.4	10.2	38	34	34.2	30.6
9	11.3	10.3	38	34	33.9	30.8
10	14.4	11.6	48	38	43.2	34.8

DEMOGRAPHIC DATA 3: SHOWING THE TYPE OF SURGERY, BLOOD LOSS (ML), DURATION OF SURGERY (MIN)

Pt.no	Procedure	Blood Loss (ml)	Duration of surgery (min)
1	Lefort I, BSSRO	283	280
2	AMO	158.4	150
3	BSSRO, Genioplasty	169.6	270
4	Genioplasty	77.6	75
5	AMO, BSSRO	227.3	290
6	AMO	174	180
7	AMO	171.8	160
8	Genioplasty	106	95
9	AMO, Subapical	200	140
10	AMO	174.2	100

DEMOGRAPHIC DATA: 4 SHOWING THE MEAN ARTERIAL PRESSURE

Pt.no	Pre-op	Before inducing NTG	After inducing NTG	Post-op
1	86.6	98.3	76.6	90
2	93.3	96.6	78.3	93.3
3	93.3	88.3	78.6	96.6
4	90	98.3	71.6	83.3
5	93.3	96.6	63.3	93.3
6	90	91.6	67.6	90
7	93.3	90	73.3	93.3
8	93.3	91.6	73.3	93.3
9	83.3	83.3	70	80
10	93.3	96.6	75.6	93.3

Table 1: Comparison of Haemoglobin%, Haematocrit% and RBC% among study subjects before and after surgery.

Variable	Time period	n	Mean (SD)	Mean difference	t value	df	p value
Hemoglobin%	Pre-operative	10	12.14 (1.68)	2.08	6.47	9	0.001*
	Post-operative	10	10.06 (1.75)				
Hematocrit%	Pre-operative	10	40.50 (5.58)	7.30	6.72	9	0.001*
	Post-operative	10	33.20 (5.83)				
RBC %	Pre-operative	10	36.42 (5.04)	6.24	6.47	9	0.001*
	Post-operative	10	30.18 (5.25)				

*HS – Highly significant using Paired t test.

Graph 1: Comparison of Haemoglobin%, Haematocrit% and RBC% among study subjects before and after surgery.

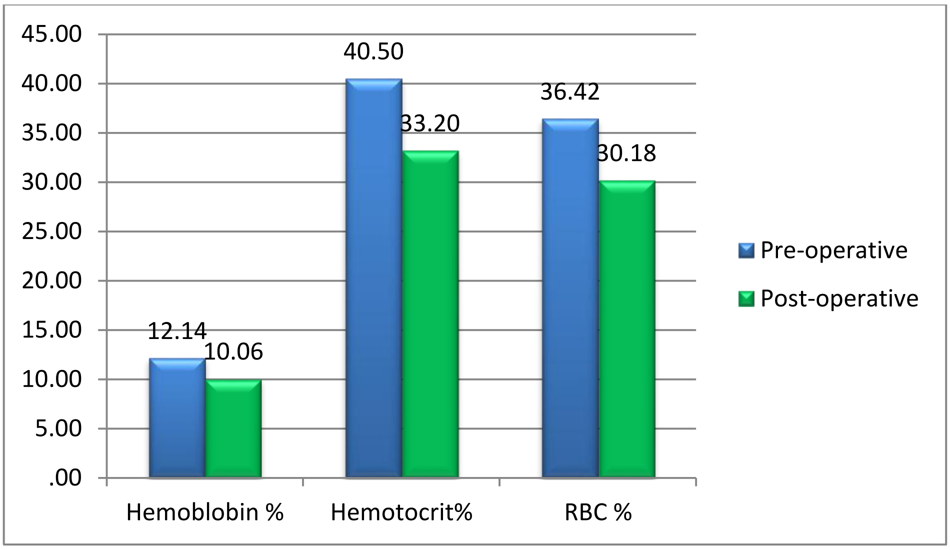


Table 2: Blood loss and Duration of surgery among study subjects

Variable	N	Range	Minimum	Maximum	Mean (Median)	Std. Deviation
Blood loss (ml)	10	205.40	77.60	283.00	174.19 (172.9)	57.33
Duration (minutes)	10	215.00	75.00	290.00	174 (155)	79.85

Graph 2: Mean Blood loss and Duration of surgery among study subjects

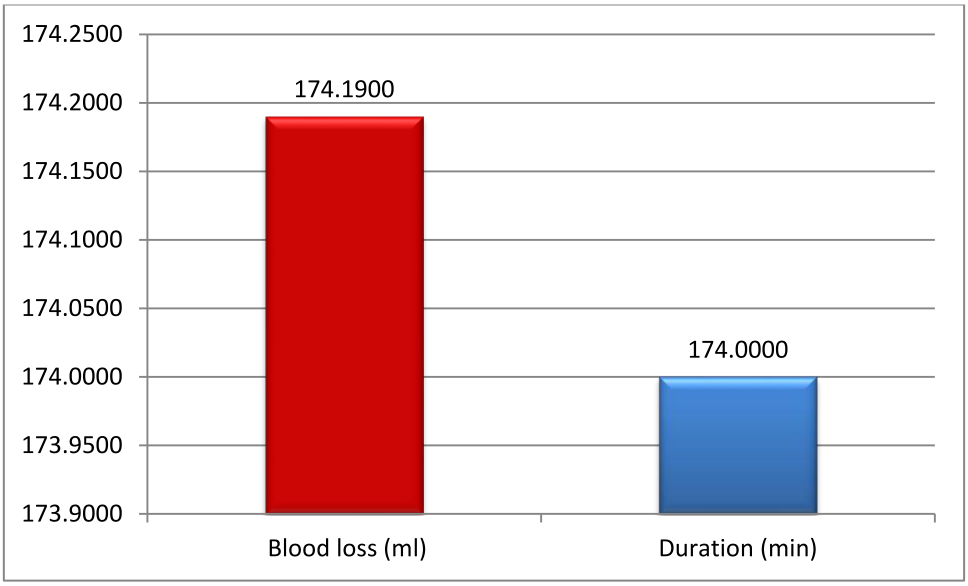
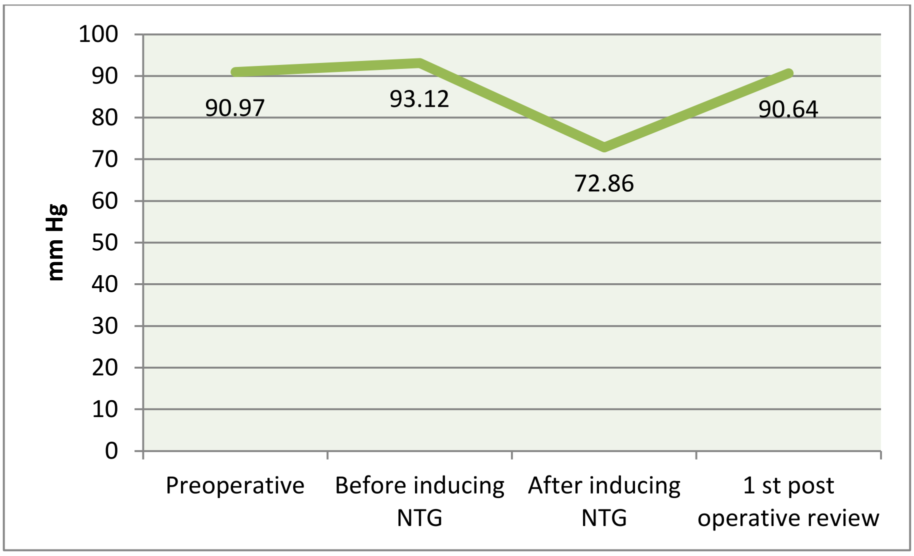


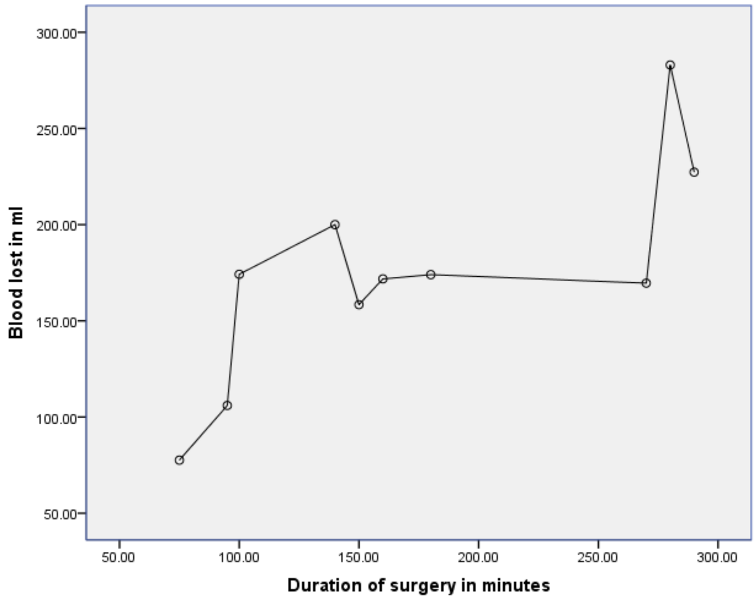
Table 3: Mean Arterial pressure of the study subjects recorded at various time periods

Time period	N	Range	Minimum (mm Hg)	Maximum (mm Hg)	Mean (mm Hg)	Std. Deviation (mm Hg)
Preoperative	10	10.00	83.30	93.30	90.97	3.53
Before inducing NTG	10	15.00	83.30	98.30	93.12	4.98
After inducing NTG	10	15.30	63.30	78.60	72.86	4.89
one day post operative	10	16.60	80.00	96.60	90.64	5.15

Graph 3: Line diagram showing the mean arterial pressure of the study subjects recorded at various time period.



Graph 4: Scatter diagram showing the correlation between the Amount of blood loss and Duration of surgery in minutes.



DISCUSSION

The result of this study indicated a reduction in intraoperative blood loss, clear and improved quality of surgical field but no statistically significant decrease in the operative time with the use of hypotensive anaesthesia.

In our studies the surgical procedures included maxillary osteotomy, segmental osteotomy or mandibular osteotomies under hypotensive anaesthesia, maintaining a mean arterial pressure of 72.86 mm Hg recorder with the use of non invasive blood pressure monitoring.

A standard 15^0 elevation was practiced, patient in supine position on the operating table which was flexed and the angle of the mandible was above the level of the heart which influenced the blood loss.

Operating time could not be standardised due to variables like electrocautery setting, multiple surgeons, instrument handling during surgery, quality of surgical field and the length of the surgical procedure.

Nasal septal osteotomy, causing laceration of nasal mucosa resulted in increased bleeding, furthermore the transection of the descending palatine vessels resulted in the increased haemorrhage and operating time.

Blood loss was measured by volumetric and gravimetric techniques with strict attention directed to the amount of irrigation used. In our study nitroglycerin was used as hypotensive agent which maintained the mean arterial pressure during osteotomy at 72.86 mm Hg. The mean operating time for single jaw surgery was 112.6 minutes, and 236.6 minutes for double jaw surgeries.

The mean blood loss for single jaw procedure was 143.65 ml and double jaw surgery was 236.76 ml on hypotensive anaesthesia. The operating time increased in the bi-jaw surgery which resulted as an increase in the blood loss in our patients. The mean body weight of our patients were 54.1 kgs.

The pre and postoperative blood investigations included Haemoglobin and Haematocrit values. The Mean preoperative haemoglobin was 12.14 gm% and the postoperative haemoglobin was 10.06 gm%, the difference in the mean haemoglobin between the pre op and post op values was calculated and the reduction in post op value was 2.08 gm%.

The Mean preoperative haematocrit was 40.50% and the mean postoperative haemoglobin was 33.20%, the difference in the mean Haematocrit between the pre and postoperative values was calculated and the reduction in post op value was 7.30%. No blood transfusion was required for any of our patients. The mean preoperative RBC value was 36.42% and mean postoperative value was 30.18%. The difference in the mean RBC between the pre and postoperative values was calculated and the reduction in post op value was 6.24%

Controlled hypotensive anaesthesia in our study ranges from 63 – 78 mmHg with mean of 72.86 mmHg which reduced the blood loss to minimum which are similar to studies conducted by Schaberg et al[44] which reported 44% reduction in blood loss.

The advantages of controlled hypotensive anaesthesia are reduction in blood loss, improved visualization of surgical field, conservation of donor blood, increased speed and accuracy of surgery.

SUMMARY AND CONCLUSION

The use of hypotensive anaesthesia is a valuable tool in orthognathic surgery for the reduction of blood loss, improving the quality of surgical field, ease of surgery, controlling the length of surgery. Hence, hypotensive anaesthesia is safe and routinely used in our institution for all orthognathic surgeries.

BIBILOGRAPHY

1. **Allisa lockwood, patka, marina Rabinovich, Katleen Wyatt and Prasad Abraham**. Sodium nitroprusside associated cyanide toxicity in adult patients – fact or fiction? A critical review of the evidence and clinical relevance. Open access journal of clinical trails 2010;(2):133-148.
2. **Beierholm.w.e, Bregaard Sorenson. M, Scroczynski.Z.** Haemodynamic changes during sodium nitroprusside induced hypotension and halothane/nitrous oxide anaesthesia. Act a anaesthesiology Scandinavia 1983 april ; 27(2):99-103.
3. **Bergman.S, Hoffman W.E, Gans B.J, Miletich D.JL.** Blood flow to oral tissues and experimental study with enflurane, sodium nitroprusside and nitroglycerine. Journal of maxillofacial surgery. 1982;40(1):13-7.
4. **Choi.W.S, Samman.N**. Risks and benefits of deliberate hypotension in anaesthesia: a systemic review. International journal of oral and maxillofacial surgery 2008;37:687-703.
5. **Campkin T.V, Flinn R.M. Isoflurane:** its use to induce hypotension in neurosurgical patients. European journal of anaesthesiology 1986;3(5):395-401.
6. **Chan.W, Smith D.E, Ware W.H.** Effects of hypotensive anaesthesia in anterior maxillary osteotomy. Journal of oral surgery 1980;38(7):504-508.
7. **Cnf Yu, TK Chow, Ask Kwan, SL Wong and Sc Fung.** Intra-operative blood loss and operating time in orthognathic surgery using induced

hypotensive general anaesthesia: prospective study. Hong Kong Medical Journal. 2000;6:307-311.

8. **Dhariwal.D.K, Gibbons.A.J, Kittur, Sugar.A.W.** Blood transfusion requirements in bimaxillary osteotomies. British journal of oral and maxillofacial surgery 2004;42:231-235.
9. **Duraiswamy Sankar, Radhika Krishnan, M. Veerabahu, B. Vikraman**. Evaluation of the efficacy of tranexamic acid on blood loss in orthognathic surgery. Aprospective, randomized clinical study. International Journal of Oral Maxillofacial Surgery. 2012;41:713–717.
10. **Ervens.J, Marks.C, Hechler.M, Plath.T.** Effect of induced hypotensive anaesthesia vs isovolaemic haemodilution on blood loss and transfusion requirement in orthognathic surgery: a prospective, single, blinded, randomized, controlled clinical study. International journal of oral and maxillofacial surgery 2010;39:1168-1174.
11. **Ekback G, Aexlsson K, Ryttberg L.** Tranexamic acid reduces blood loss in total hip replacement surgery. Anaesthesia analgesia 2000;91(5):1124-1130.
12. **Enlund MG, Ahlstedt BL, Andersson LG, Krekmanov LI.** Induced hypotension may influence blood loss in orthognathic surgery, but it is not crucial. Scand J Plast Reconstruction Surg Hand Surg. 1997;31(4):311-7.
13. **Emeka Nkenke, Peter Kessler, Jorg Wiltfang and Volker Weisbach.** Haemoglobin value reduction and necessity of transfusion in bimaxillary orthognathic surgery. Journal of Oral Maxillofacial Surgery. 2005;63(5):623-8.

14. **Fahmy NR.** Nitroglycerin as a hypotensive drug during general anaesthesia. Anaesthesiology. 1978;49(1):17-20.

15. **Firn S**. Enflurane for controlled hypotension. Post grad med journal. 1983; 59(695):608-609.

16. **Gallagher DM, Milliken RA.** Induced hypotension for orthognathic surgery. Journal of Oral Surg. 1979;37(1):47-51.

17. **Golia JK, Woo R, Farole A, Seltzer JL.** Nitroglycerin-controlled circulation in orthognathic surgery. Journal of Oral Maxillofacial Surgery. 1985;43(5):342-345.

18. **Goran Zellin, Rasmusson L, Pålsson J, Kahnberg KE.** Evaluation of hemorrhage depressors on blood loss during orthognathic surgery: a retrospective study. Journal of Oral Maxillofacial Surgery. 2004; 62(6):662-666.

19. **Gourdeau M, Martin R, Lamarche Y, Tétreault L.** Oscillometry and direct blood pressure: a comparative clinical study during deliberate hypotension. Canadian anaesthetist Society. 1986;33(3):300-307.

20. **Guggiari M, Dagreou F, Lienhart A, Gallais S, Mottet P, Philippon J, Viars P.** Use of nitroglycerine to produce controlled decreases in mean arterial pressure to less than 50 mm Hg. British Journal of Anaesthesia. 1985;57(2):142-147.

21. **Guyuron B, Vaughan C, Schlecter B.** The role of DDAVP (Desmopressin) in orthognathic surgery. Anaesth Analg 2000;91(5):1124-1130.

22. **Hoffman W.E, Bergman S, Miletich D J.** Regional vascular changes during hypotensive anaesthesia. Journal of cardio vascular pharmacology 1982; 4(2):310.

23. **Jacobi K.E, Bohn B.E, Riickaver A.J.** Moderate controlled hypotension with sodium nitroprusside does not improve surgical conditions or decrease blood loss in endoscopic sinus surgery. Journal of clinical Anaesthesia 2000 may; 12(3):202-207.

24. **James Gardner.W** The control of bleeding during operation by induced hypotension. Journal of American medical association 1946;9.

25. **Jean – Marc Bernard, Micheal Pinaud, Thierry Francois.** Deliberate hypotension with nicardipine or nitroprusside during hip arthroplasty 1991;73: 341-351.

26. **Kerr AR.** Anaesthesia with profound hypotension for middle ear surgery. British Journal of Anaesthesia. 1977;49(5):447-452.

27. **Koichiroueki Ueki , Marukawa K, Shimada M, Nakagawa K, Yamamoto E..** The assessment of blood loss in orthognathic surgery for prognathia. Journal of Oral Maxillofacial Surgery. 2005;63(3):350-354.

28. **Lam AM, Gelb AW.** Cardiovascular effects of isoflurane- induced hypotension for cerebral aneurysm surgery. Anaesthesia Analog 1993;62(8): 742-748.

29. **Leigh JM.** The history of controlled hypotension. British Journal of Anaesthesia. 1975;47(7):745-749.

30. **Lessard MR, Trépanier CA, Baribault JP, Brochu JG, Brousseau CA, Coté JJ, Denault PH.** Isoflurane-induced hypotension in orthognathic surgery. Anesth Analg. 1989;69(3):379-383.

31. **MacRae WR.** Induced hypotension. British Journal of Hosp Med. 1985;33(6):341-343.

32. **Michael.E.Goldberg, Mcnulty S.E et al.** A comparison of labetalol and nitroprusside for inducing hypotension during major surgery 1990;70:537-542.

33. **Myron Yaster, Simmons RS, Tolo VT, Pepple JM, Wetzel RC, Rogers MC**. A comparison of nitroglycerin and nitroprusside for inducing hypotension in children: a double-blind study. Anaesthesiology. 1986;65(2):175-179.

34. **Moenning JE, Bussard DA, Lapp TH, Garrison BT.** Average blood loss and the risk of requiring perioperative blood transfusion in 506 orthognathic surgical procedures. Journal of Oral Maxillofacial Surgery. 1995;53(8):880-883.

35. **Nabil Samman, Cheung LK, Tong AC, Tideman H.** Blood loss and transfusion requirements in orthognatic surgery. Journal of Oral Maxillofacial Surgery. 1996;54(1):21-24; discussion 25-26.

36. **Neil M.C, Wald D.E, Bennet E.J.** Controlled hypotensive anaesthesia in scoliosis surgery. Bone and joint surgery AM 1974;56(6):1167-1172.

37. **Pasch T, Huk W.** Cerebral complications following induced hypotension. European Journal of Anaesthesiology. 1986;3(4):299-312.
38. **Praveen K, Narayanan V, Muthusekhar MR, Baig MF.** Hypotensive anaesthesia and blood loss in orthognathic surgery: a clinical study. British Journal of Oral Maxillofacial Surgery. 2001;39(2):138-140.
39. **Precious DS, Splinter W, Bosco D.** Induced hypotensive anaesthesia for adolescent orthognathic surgery patients. Journal of Oral Maxillofacial Surgery. 1996;54(6):680-683; discussion 683-684.
40. **Ramsey M.** Blood pressure monitoring; Automated oscillometric devices. Journal of clinical monitoring 1991;7(1):56-67.
41. **Robert Dolman M, Bentley KC, Head TW, English M.** The effect of hypotensive anaesthesia on blood loss and operative time during Le Fort I osteotomies. Journal Oral Maxillofacial Surgery. 2000 Aug;58(8):834-839
42. **Rohling RG, Zimmermann AP, Biro P, Haers PE, Sailer HF**. Alternative methods for reduction of blood loss during elective orthognathic surgery. International Journal of Adult Orthodontics Orthognathic Surgery. 1999;14(1):77-82.
43. **Sanders GM, Sim KM.** Is it feasible to use magnesium sulphate as a hypotensive agent in oral and maxillofacial surgery? Ann Academic Med Singapore. 1998;27(6):780-785.
44. **Schaberg SJ, Kelly JF, Terry BC, Posner MA, Anderson EF.** Blood loss and hypotensive anaesthesia in oral-facial corrective surgery. Journal of Oral Surgery. 1976;34(2):147-156.

45. **Siew-Ging Gong, Krishnan V, Waack D**. Blood transfusions in bimaxillary orthognathic surgery: are they necessary? International Journal Adult Orthodontic Orthognathic Surgery. 2002;17(4):314-317.

46. **Sivarajan.M, Amory, Everret**. Blood pressure, not cardiac output, determines blood loss during induced hypotension. Anaesthesia Analgesia 1980;59(3):203-206.

47. **Sollevi A.** Hypotensive anaesthesia and blood loss. Acta Anaesthesiol Scand Suppl. 1988;89:39-43.

48. **Stewart A, Newman L, Sneddon K, Harris M.** Aprotinin reduces blood loss and the need for transfusion in orthognathic surgery. British Journal of Oral Maxillofacial Surgery. 200;39(5):365-370.

49. **Thompson GE, Miller RD, Stevens WC, Murray WR.** Hypotensive anaesthesia for total hip arthroplasty: a study of blood loss and organ function (brain, heart, liver, and kidney). Anaesthesiology. 1978;48(2):91-96.

50. **Tremper K.K, Waxman K.S, Applebaum RA.** Transcutaneous PO_2 monitoring during sodium nitroprusside infusion. Crit care med. 1985;13(2) :65-67

51. **Van de Perre JP, Stoelinga PJ, Blijdorp PA, Brouns JJ, Hoppenreijs TJ.** Perioperative morbidity in maxillofacial orthopaedic surgery: a retrospective study. J Craniomaxillofacial Surgery. 1996;24(5):263-270.

52. **Vandesteene A, Mouawad E, Noterman J, Deloof T, Ewalenko P, Genette F.** Use of sodium nitroprusside in neurosurgical cases during anaesthesia with enflurane. Acta Anaesthesiology. 1980;31Suppl:85-92.

53. **Varol A, Selcuk BASA, Salih OZTURK.** The role of controlled hypotension upon transfusion requirement during maxillary downfracture in double-jaw surgery. J Craniomaxillofacial Surgery. 2010; 38:345-349.

54. **Ward C.F, Alfery D.D, Saidman L.J.** Deliberate hypotension in head and neck surgery. Head Neck Surgery 1980;2(3):158-195.