Original Article

Is hypotensive anaesthesia guided by invasive intraarterial monitoring required for orthognathic surgery? - A retrospective review of anaesthetic practice and intraoperative blood loss in orthognathic surgery in a tertiary hospital

Yi Lin Lee, Suhitharan Thangavelautham, Sudha Harikrishnan[1], Ranjith Karthekeyan[2], Harikrishnan Kothandan[2]

Department of Surgical Intensive Care, Singapore General Hospital, [1]Department of Anaesthesiology, Singapore General Hospital, [2]Department of Anaesthesiology and Critical Care Medicine, Singapore, Sri Ramachandra Medical Centre Porur, Chennai, Tamil Nadu, India

Address for correspondence:
Dr. Yi Lin Lee,
Outram Road, Singapore
169608.
E-mail: lee.yi.lin@singhealth.com.sg

Submitted: 05-Apr-2021
Revised: 22-Apr-2021
Accepted: 01-Jul-2021
Published: 23-Jul-2021

ABSTRACT

Background and Aims: Orthognathic surgeries for maxillofacial deformities are commonly performed globally and are associated with significant blood loss. This can distort the surgical field and necessitate blood transfusion with its concomitant risks. We aimed to review if invasive intraarterial (IA) line monitoring and/or hypotensive anaesthesia is required for orthognathic surgeries, and their effects on intraoperative blood loss and transfusion requirements. **Methods:** This was a retrospective observational study conducted in patients admitted for orthognathic surgeries in a public tertiary hospital. Anaesthetic techniques and intraoperative haemodynamics were studied for their effects on intraoperative blood loss. **Results:** The data from 269 patients who underwent orthognathic–bimaxillary surgeries was analysed. Inhalational anaesthetic combined with remifentanil was administered for 86.6%, total intravenous anesthesia to 11.2% patients, while the rest received inhalational anaesthesia. Hypotensive anaesthesia was achieved in 48 subjects (17.8%) and associated with shorter duration of surgery (349 vs 378 min, $P = 0.02$) and a trend towards lower blood loss (874 mL vs 1000 mL, $P = 0.058$) but higher transfusion requirement (81.3% vs 58.8%, $P = 0.004$). An IA line was used in 119 patients (44.2%) and was not associated with a higher probability of achieving hypotensive anaesthesia (19.3% vs 16.7%, $P = 0.06$). However, less blood loss (911 vs 1029 mL, $P = 0.05$) occurred compared to noninvasive blood pressure monitoring. **Conclusion:** Invasive blood pressure monitoring is as effective as noninvasive methods to achieve hypotensive anaesthesia. It does not aid in achieving lower target blood pressure. There is a lack of association between a reduction in blood loss and higher blood transfusion during hypotensive anaesthesia and this will require further evaluation.

Key words: Anaesthesia, blood loss, blood pressure, orthognathic surgery, surgical

Access this article online
Website: www.ijaweb.org
DOI: 10.4103/ija.IJA_201_21
Quick response code

INTRODUCTION

Orthognathic surgery is widely accepted for the correction of dento-facial deformities. The head and neck region is highly vascularised and dissection in this area can lead to considerable blood loss from bone and soft tissues obstructing the visual field, prolonging operating time, and increasing the chances and risks of blood transfusion.[1-4]

How to cite this article: Lee YL, Thangavelautham S, Harikrishnan S, Karthekeyan R, Kothandan H. Is hypotensive anaesthesia guided by invasive intraarterial monitoring required for orthognathic surgery? – A retrospective review of anaesthetic practice and intraoperative blood loss in orthognathic surgery in a tertiary hospital. Indian J Anaesth 2021;65:525-32.

Controlled hypotension has been widely used in a variety of surgical disciplines and refers to a fall in mean arterial pressure (MAP) to 50–65 mmHg in patients without hypertension.[3] It is commonly used in orthognathic surgery and is associated with decreased intraoperative blood loss, improved operative field quality, lowered blood transfusion rates, shortened surgical duration, and hospital stay. However, there is increasing evidence in noncardiac surgeries that even brief durations of systolic pressure <100 mmHg or MAP <60–70 mmHg can be detrimental, which makes the practice of hypotensive anaesthesia unfavourable among anaesthetists.[5] This retrospective study aims to review if invasive monitoring and/or hypotensive anaesthesia is required for orthognathic surgeries, and their effects on intraoperative blood loss and transfusion requirements.

METHODS

This was a single-centre retrospective study conducted in a large tertiary centre. The study protocol was developed in accordance with the Strengthening the Reporting of Observational studies in Epidemiology guidelines for reporting cross-sectional studies. It was approved by the Centralised Institutional Review Board with waiver of informed consent (CIRB 2016/3153) on 19 January 2017 and registered under Clinicaltrials.gov (NCT04813289).

All patients scheduled for orthognathic surgeries from January 2014 to March 2017 were included and comprised of both adults and children. Patients were excluded from the study if surgery was not performed or there were missing records. They were identified via the hospital's Operating Theatre Management System. Gender, age, weight, height, surgical duration, estimated blood loss (EBL), type and amount of blood products transfused, baseline and postoperative haemoglobin levels, and hospital length of stay were obtained from the electronic database maintained by the Department of Information Technology. Intraoperative parameters such as blood pressure, heart rate, and inhalational agent concentrations were obtained from Anaesthesia Information Management System, which recorded vitals every 12s. Average MAP for the entire duration of surgery was calculated for every patient using the data obtained every 12s for patients who had an intraarterial line (IA) and every 3 min for patients who had a noninvasive blood pressure monitor (NIBP).

Due to the relatively small numbers of patients who had isolated single-jaw surgery, data analysis was conducted on patients who had bimaxillary surgeries to determine the effects of anaesthetic techniques and review the risk factors for blood loss and the need for blood transfusion.

Several terms utilised in this study were precisely defined. Hypotensive anaesthesia referred to an average intraoperative MAP of less than 60 mmHg. Average MAP was calculated by obtaining the mean value for all available MAP readings from the induction of anaesthesia to the end of surgery. The value of MAP was based on IA reading if patients had one or the NIBP if no IA parameters were available. Patients who underwent bimaxillary surgery had both bilateral sagittal split osteotomy (BSSO) and Lefort procedures, and those who went for single-jaw surgery had either BSSO or Lefort procedures.

The decision of choice of anaesthesia techniques – total intravenous anaesthesia (TIVA), volatile agents, opioids as well as that for blood transfusion – was determined by the attending anaesthetist. The decision for blood transfusion was based on the estimated intraoperative blood loss sustained (based on the amount of blood in the suction bottles and the number/extent of blood soaked gauzes) and intraoperative haemoglobin value when available. In our centre, the threshold for intraoperative blood transfusion (allogenous/autologous) is based on a target haemoglobin level of above 7–8 g/dL. While hypotensive anaesthesia is routinely performed for orthognathic surgeries, the primary anaesthesiologist would decide on the need for an IA line depending on the estimated duration/extent of surgery and need for frequent blood sampling. A radial IA line was inserted after performing Allen's test for all patients who received invasive blood pressure monitoring.

TIVA referred to anaesthesia maintained with target controlled infusion of propofol and remifentanil where the depth of anaesthesia was titrated to a bispectral index between 40 and 60. Either sevoflurane or desflurane was used during inhalational anaesthesia as per the attending anaesthetist with the depth of anaesthesia titrated to keep a minimum alveolar concentration between 0.8 and 1.2. Neuromuscular blocking agents, either atracurium or rocuronium, were used.

Statistical analysis was performed using Statistical Package for the Social Sciences for Mac version 20.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were reported as mean ± standard deviation. Categorical variables were reported as number (percentage). Student's *t*-test and one-way analysis of variance with posthoc analysis was used for comparison of continuous variables between the studied groups. Pearson Chi-square test was used for comparison of categorical variables among the studied groups. A value of $P < 0.05$ was considered significant.

RESULTS

Three hundred eight patients fulfilled the inclusion criteria and 23 patients (7.5%) were excluded due to missing data. In total, 285 patients were studied: 269 patients underwent bimaxillary surgeries, 13 LeFort I, and 3 BSSO.

Two hundred sixty-nine patients who underwent bimaxillary surgery were analysed. The mean age was 23.6 ± 5 years with an age range between 16 and 45 years old. Anaesthesia techniques were analysed based on TIVA, inhalational anaesthetic with and without the use of remifentanil to determine if remifentanil was associated with the attainment of better haemodynamics. TIVA was administered to 30 (11.2%) patients, 233 (86.6%) had inhalational anaesthesia with remifentanil (InhA-R), and 6 (2.2%) patients had inhalational anaesthesia without remifentanil (InhA). Patients on remifentanil were started on the infusion during induction and this was continued to the end of surgery. There were no differences in baseline demographics such as gender, age, body mass index (BMI) and American Society of Anesthesiologists (ASA) physical status among patients administered the three anaesthetic techniques [Table 1]. Similarly, surgical duration, mean blood pressures and heart rate, preoperative and postoperative haemoglobin (haemoglobin levels done immediately when patients were in the ward) values, amount of intravenous fluid (both Hartmanns and colloids) administered, length of hospital stay, or number of cases that required blood transfusion were comparable between the groups. They were given a mean dose of 8.4 ± 3.3 mg of morphine in titrated boluses during surgery. Patients who were not given remifentanil required 13.0 ± 8.8 mg morphine (none were given oxycodone). Twelve patients who received remifentanil infusion were given a mean dose of 10.6 ± 5.3 mg oxycodone (morphine equivalent dose (MED) 15.9 ± 7.9 mg) in titrated boluses throughout surgery. None received both morphine and oxycodone. Taking into account the MED between the groups who were given remifentanil infusion, no remifentanil and oxycodone, there was a significant difference in morphine requirements, with those with remifentanil requiring the least MED ($P < 0.01$).

A total of 48 of 269 patients (17.8%) achieved hypotensive anaesthesia, 10 patients (3.7%) required glyceryl trinitrate, 95 patients (35.3%) beta-blockers, and 15 patients (5.6%) hydralazine on top of their baseline maintenance anaesthetic. Among them, 23 patients (47.9%) had an IA line placed. The percentage of patients who required additional blood pressure lowering medications (glyceryl trinitrate, beta-blockers, or hydralazine) was similar in both hypotensive and normotensive anaesthesia groups.

Of note, patients who achieved hypotensive anaesthesia tended to be females, had a lower BMI and preoperative haemoglobin levels compared to those in whom hypotensive anaesthesia was not achieved. Moreover, they had a significantly shorter duration of surgery (349.7 ± 70.4 vs 378.7 ± 101.2 min, $P = 0.02$). This group also received more blood products (81.3% vs 58.8%, $P < 0.01$) than normotensive patients with 64.6% receiving autologous products compared with 46.2% ($P = 0.021$). There was no difference in the amount of IV fluids or total blood transfusion received [Table 2].

Blood pressures were monitored using an IA line in 119 out of 269 patients (44.2%), while the rest were monitored using NIBP. The baseline characteristics of both groups were similar in terms of gender, age, BMI, and ASA status [Table 3]. Regardless of whether invasive blood pressure monitoring was used, patients achieved similar average MAPs (MAP 64.6 ± 5.4 mmHg in patients with IA vs 64.3 ± 4.3 mmHg with NIBP, $P = 0.59$) and hypotensive anaesthesia (19.3% vs 16.7%, $P = 0.06$) as those using NIBP. This was associated with a significantly lower mean EBL (911.7 vs 1029.2 mL, $P = 0.050$). However, the number of patients requiring blood transfusions (64.7% vs 61.3%, $P = 0.61$), preoperative (13.8 ± 1.6 g/dL vs 14.0 ± 1.4 g/dL, $P = 0.21$), postoperative haemoglobin levels (11.6 ± 1.6 g/dL vs 11.6 ± 1.4 g/dL, $P = 0.82$), and mean volume of blood transfusion (307.2 ± 222.8 mL vs 320.6 ± 312.7 mL, $P = 0.71$) was comparable.

Among the patients in whom an intraoperative haemoglobin was obtained, the lowest mean intraoperative haemoglobin was 10.6 ± 1.9 g/dL. Two

Table 1: Comparison of demographic data, intraoperative haemodynamic characteristics, estimated blood loss, and needs for blood transfusion between patients using different anaesthetic techniques

Total bimax	TIVA	InhA-R	InhA	*P*
(269)	(30)	(233)	(6)	
Sex				0.305
Male	14 (46.7%)	133 (57.1%)	2 (33.3%)	
Female	16 (53.3%)	100 (42.9%)	4 (66.7%)	
Age (yr)	23.0±4.2	23.7±5.1	23.8±4.9	0.777
Weight (kg)	58.6±10.9	63.4±11.8	64.8±5.5	0.209
BMI	21.6±2.8	21.9±3.4	23.8±2.9	0.309
ASA				0.819
I	24 (80.0%)	166 (71.2%)	5 (83.3%)	
II	6 (20.0%)	65 (27.9%)	1 (16.7%)	
III	0	2 (0.9%)	0	
Dose of TCI (Cet) propofol (µg/mL)	3.0±0.4	NA	NA	NA
Inhalational agent				
Desflurane	NA	232 (99.6%)	4 (66.7%)	<0.001
Dose		6.2±0.8	6.9±0.2	0.088
Sevoflurane	NA	1 (0.4%)	2 (33.3%)	<0.001
Dose		1.9	2.1	NA
EBL (mL)	977.0±493.7	978.4±495.6	933.3±242.2	0.976
Transfusion requirement	22 (73.3%)	143 (61.4%)	4 (66.7%)	0.435
Length of hospital stay (h)	62.6±12.7	62.1±15.8	58.5±13.3	0.841

* TIVA - total intravenous anaesthesia, VA - inhalational anaesthesia, BMI - body mass index, ASA - American Society of Anesthesiologists (ASA) physical status classification system, SBP - systolic blood pressure, DBP - diastolic blood pressure, TCI (Cet) - target controlled infusion (target effect site concentration), EBL - estimated blood loss, Bimax - bimaxillary surgery, InhA-R - inhalational anaesthesia with remifentanil, InhA - inhalational anaesthesia without remifentanil. Data presented as mean±standard deviation (SD) or number (proportion). *P*<0.05 means statistically significant

patients had a haemoglobin level of less than 7 g/dL while another four had Hb levels of between 7.1 and 8 g/dL. Mean postoperative haemoglobin level for all patients was 11.6 ± 1.5 g/dL. Ninety-four (34.9%) patients received blood transfusion intraoperatively, with 133 out of 169 patients (78.7%) receiving an autologous transfusion.

DISCUSSION

In our study, we found that InhA-R was the most popular anaesthetic technique used for orthognathic surgeries (86.6%). Achieving an average intraoperative MAP of below 60 mmHg was (regardless of anaesthetic technique) associated with a shorter duration of surgery, a trend toward lower blood loss but yet higher autologous blood transfusion requirements. Interestingly, we found that the use of an IA line is as good as NIBP to monitor hypotensive anaesthesia although patients in the former had significantly lower blood loss.

An IA line provides continuous beat-to-beat monitoring of a patient's blood pressure, heart rate, rhythm and provides information about volume status and cardiac contractility. It remains the "gold standard" for haemodynamic monitoring in hypotensive anaesthesia by allowing accurate titration of hypotensive agents. The use of an IA line is not innocuous and complications such as haematomas, pseudoaneurysms, and nerve injuries have been described in 2.7–12.3 per 10,000 patients.[6] In comparison, NIBP monitor uses the oscillometry system and gives a snapshot value as it is cycled every 3–5 min during anaesthesia.[7] NIB*P* values can be inaccurate due to the inappropriate sizing of the cuff (ideally this should be 80% in length and 40% in width),[8] external cuff compression, cardiac arrhythmias, and shivering/movement. A meta-analysis found that there was a significant difference between IA and NIBP values and cautioned against pure reliance on NIBP.[9]

Although patients undergoing orthognathic surgeries are anticipated to have significant blood loss, these patients are generally fit and healthy with normal haemoglobin levels and are able to tolerate hypotensive anaesthesia without close continuous monitoring. In our centre, some anaesthetists choose to monitor their patients using only the NIBP to achieve hypotensive anaesthesia to avoid the risks associated with the insertion of invasive lines. The results of our study concur that invasive arterial lines are not necessary to achieve hypotensive anaesthesia.

Remifentanil infusion for orthognathic surgeries is associated with a reduction in intraoperative blood loss due to its ability in lowering intraoperative blood

Table 2: Comparison of demographic data, intraoperative haemodynamic characteristics, estimated blood loss, and needs for blood transfusion between patients using mean arterial pressure (MAP) targets

Total bimax	MAP <60 mmHg	MAP >60 mmHg	P
(269)	(48)	(221)	
Sex			<0.001
Male	15 (31.3%)	135 (61.1%)	
Female	33 (68.8%)	86 (38.9%)	
Age (yr)	22.5±5.0	23.9±5.0	0.084
Weight (kg)	55.1±8.7	63.6±11.7	<0.001
BMI	20.6±2.5	22.2±3.4	<0.001
ASA			0.081
I	41 (85.4%)	154 (69.7%)	
II	7 (14.6%)	65 (29.4%)	
III	0 (0%)	2 (0.9%)	
Surgery duration (min)	349.7±70.4	378.7±101.2	0.020
Anesthesia methods			0.946
TIVA	6 (12.5%)	24 (10.9%)	
VA w. remifentanil	41 (85.4%)	192 (86.9%)	
VA only	1 (2.1%)	5 (2.3%)	
Use of intraarterial line	23 (47.9%)	96 (43.4%)	0.571
Hypotensive technique			
GTN	2 (4.2%)	8 (3.6%)	0.858
Beta-blocker	15 (31.3%)	80 (36.4%)	0.502
Hydralazine	2 (4.2%)	13 (5.9%)	0.639
Pulse rate (per min)	75.9±9.0	76.9±9.2	0.505
Mean MAP (mmHg)	58.1±1.6	65.8±4.1	<0.001
Mean SBP (mmHg)	88.4±6.1	95.6±7.0	<0.001
Mean DBP (mmHg)	46.9±4.8	52.6±5.6	<0.001
Preop Hb (g/dL)	13.2±1.5	14.1±1.4	0.001
Postop Hb (g/dL)	11.1±1.3	11.7±1.5	0.004
IV. Fluids (mL)	2539.6±701.5	2668.8±910.5	0.278
EBL (mL)	874.4±385.3	999.6±508.0	0.058
No. who required transfusion	39 (81.3%)	130 (58.8%)	0.004
Autologous blood products	31 (64.6%)	102 (46.2%)	0.021
Volume of transfusion (mL)	335.7±209.1	310.1±313.4	0.488
Length of hospital stay (h)	62.4±14.5	62.0±15.6	0.884

* TIVA - total intravenous anesthesia, VA - inhalational anesthesia, BMI - body mass index, ASA - American Society of Anesthesiologists (ASA) physical status classification system, GTN - glyceryltrinitrate, SBP - systolic blood pressure, DBP - diastolic blood pressure, Hb - haemoglobin, EBL - estimated blood loss, Bimax - bimaxillary surgery, preop-preoperative, postop-postoperative. Data presented as mean±standard deviation (SD) or number (proportion). *P*<0.05 means statistically significant

pressure and heart rate variability, shortening the surgical duration, and postsurgical recovery times.[10-12] In animal studies, remifentanil infusions demonstrated dose-dependent reductions in haemodynamics (heart rate and blood pressure) and blood flows in the mandibular, masseter, tongue, upper and lower alveolar tissues.[13]

The choice of volatile agents may also affect the amount of intraoperative blood loss, with desflurane being associated with the lowest amount of blood loss compared to sevoflurane/isoflurane.[14] Among the 88.8% of patients who received volatile agents, the majority (98.7%) received desflurane and the rest sevoflurane. Those who received sevoflurane had a mean blood loss of 933.3 ± 321.5 mL versus 977.8 ± 492.9 mL in those who received desflurane (P = 0.99). However, the small number (three patients) in the sevoflurane group increases the likelihood of a type 2 error.

A meta-analysis by Lin *et al*.[15] showed that hypotensive anaesthesia in orthognathic surgery was useful to reduce intraoperative blood loss and improve the surgical field quality. Another study by Ervens comparing normotensive and induced hypotensive anaesthesia combined with isovolaemic haemodilution demonstrated that patients in the hypotensive anaesthesia group had a significantly lower mean blood loss (392 mL) compared to the normotensive anaesthesia (1022 mL) or hypotensive anaesthesia with isovolaemic haemodilution (1192 mL, $P < 0.05$) groups.[16] Similarly, our mean EBL tended to be lower among patients with hypotensive compared to normotensive anaesthesia (874 vs 1000 mL, $P = 0.058$). We found a correlation of female gender, low BMI, and low preoperative haemoglobin for those patients who achieved hypotensive anaesthesia. Anaemic patients have a lower blood viscosity. This results in lower systemic vascular resistance which is further exacerbated during general anaesthesia, potentially making it easier to achieve hypotensive anaesthesia. None of our patients were on any antiplatelets or anticoagulants and did not have any coagulation abnormalities preoperatively and end-tidal carbon dioxide was maintained at a mean of 34 mmHg. We postulate that being young and thin, females have a lower baseline blood pressure, hence resulting in an easier attainment of haemodynamic targets.

While hypotensive anaesthesia is undeniably associated with a reduction in intraoperative blood loss, it is not without its risks. Its use should be carefully reviewed in patients with significant comorbidities such as ischaemic heart disease, cerebrovascular accidents, or in patients with chronic hypertension as there is often a right shift in their organ perfusion pressure requirements. Besides its blood pressure lowering effects, hypotensive anaesthesia is associated with a reduction in platelet aggregation, hence preventing subclinical platelet-induced consumptive coagulopathy, and leading to a reduction

Table 3: Comparison of demographic data, intraoperative haemodynamic characteristics, estimated blood loss, and needs for blood transfusion between patients using different blood pressure monitoring techniques

Total bimax	IABP	NIBP	*P*
(269)	(119)	(150)	
Sex			0.282
Male	62 (52.1%)	88 (58.7%)	
Female	57 (47.9%)	62 (41.3%)	
Age (yr)	23.5±4.7	23.6±5.2	0.813
Weight (kg)	61.7±12.7	62.3±10.8	0.658
BMI	21.8±3.4	22.0±3.2	0.609
ASA			0.178
I	82 (68.9%)	113 (75.3%)	
II	35 (29.4%)	37 (24.7%)	
III	2 (1.7%)	0 (0.0%)	
Surgery duration (min)	376.3±87.4	371.3±104.2	0.667
Anaesthesia methods			0.238
TIVA	16 (13.4%)	14 (9.3%)	
VA w. remifentanil	102 (85.7%)	131 (87.3%)	
VA only	1 (0.8%)	5 (3.3%)	
Hypotensive anaesthesia (Average MAP<60 mmHg) achieved	23 (19.3%)	25 (16.7%)	0.06
<49.9	0	0	
50-54.9	1	2	
55-59.9	22	23	
60-64.9	50	60	
65-69.9	29	52	
70-74.9	11	12	
75-79.9	4	1	
>80	2	0	
Hypotensive technique			
GTN	7 (5.9%)	3 (2.0%)	0.113
Beta-blocker	56 (47.5%)	39 (26.0%)	0
Hydralazine	8 (6.7%)	7 (4.7%)	0.594
Pulse rate (per min)	76.3±8.3	77.0±9.7	0.484
Preop Hb (g/dL)	13.8±1.6	14.0±1.4	0.213
Postop Hb (g/dL)	11.6±1.6	11.6±1.4	0.817
IV. Fluids (mL)	2595.8±813.9	2685.3±924.9	0.400
EBL (mL)	911.7±486.0	1029.2±488.7	0.050
No. who required transfusion	77 (64.7%)	92 (61.3%)	0.612
Autologous blood transfusion	60 (50.4%)	73 (48.7%)	0.775
Volume of transfusion (mL)	307.2±277.8	320.6±312.7	0.710
Length of hospital stay (h)	62.8±15.1	61.5±15.7	0.505

* TIVA - total intravenous anesthesia, VA - inhalational anesthesia, BMI - body mass index, ASA - American Society of Anesthesiologists (ASA) physical status classification system, GTN - glyceryltrinitrate, SBP - systolic blood pressure, DBP - diastolic blood pressure, Hb - haemoglobin, EBL - estimated blood loss, Bimax - bimaxillary surgery, preop-preoperative, postop-postoperative, IABP-intraarterial blood pressure, NIBP-non invasive blood pressure. Data presented as mean±standard deviation (SD) or number (proportion). *P*<0.05 means statistically significant

in intraoperative blood loss.[17] Also, agents commonly used to produce controlled hypotension may have side effects like vasodilatation, tachyphylaxis, sedation, delayed recovery, heart blocks, and rebound hypertension.[18,19] This could explain why almost 83% of the anaesthetists in our study did not apply hypotensive anaesthesia in view of safety concerns, despite the proven benefit of reduction of blood loss. However, the population studied in our study is a unique one in which the majority of patients were young (mean age of 23.6 years) and healthy (ASA class 1,72.5%) with orthognathic surgery being performed as an elective case (100%). This group of patients will generally be able to tolerate hypotensive anaesthesia as they have good organ functional reserves.

Our cohort of patients who had hypotensive anaesthesia showed a higher mean blood loss compared to Ervens's study (874 mL vs 392 mL).[16] This could be due to many factors including surgical techniques, margin of haemodynamic swings allowed or undetected swings due to NIBP monitoring, and use of tranexamic acid (53 out of 269 patients, 19.7%). We are unable to pinpoint the reasons due to the retrospective nature of our study. However, blood loss of our normotensive group is comparable to Ervens's normotensive group (995 mL versus 1022 mL).[16] Moreover, our data shows a higher transfusion rate of 62.8% despite the fact that most of our patients were not anaemic intra- or postoperatively. While higher transfusion rates could be attributed to subjective assessment of blood loss by anaesthetists, the fact that patients were not anaemic peri- or postoperatively suggests that they may be overtransfused. Among the 105 patients in whom an intraoperative haemoglobin check was performed, only 2 patients (1.9%) had a level of less than 7 g/dL and 8 patients (7.6%) less than 8 g/dL. Despite this, 40.0% had blood transfused. This was a chance finding and further work is required to investigate the causes. A higher than expected transfusion rate may not necessarily be a reflection of the need for blood transfusion but rather to minimise blood wastage as 78.7% of patients received autologous blood. In our institution, patients with anticipated significant blood loss were identified by surgeons to have autologous blood collected prior to surgery for possible transfusion perioperatively. These blood products if not utilised would be discarded by the blood blank. Despite higher blood transfusion rates, there was no clinical impact on patients as hospital length of stay was comparable.

This study is limited by the fact that it is a single-centre retrospective study, and our institution's practices may not reflect that of other centres. The retrospective nature of this study also influences the ability to collect all possible confounders which may affect blood loss such as the total amount of remifentanil administered or anaesthetic techniques. Although all patients received hypotensive anaesthesia, based on the definition of hypotensive anaesthesia in the study (average MAP <60 mmHg), only 48 patients fulfilled these criteria. This could be because hypotensive anaesthesia may have been achieved during surgical dissection and allowed to go back to normal ranges out of this period, hence resulting in a smaller number of patients who fulfilled the criteria. However, we were able to analyse a sample of 48 patients which should be adequate to validate our results. Our study also highlighted that a large majority of anaesthesia practitioners chose to combine InhA with remifentanil. Although this makes it more challenging to interpret the results obtained, it reflects how anaesthesia is practised on the ground.

CONCLUSION

In conclusion, invasive blood pressure monitoring is as effective as noninvasive methods to achieve hypotensive anaesthesia. The former is also associated with decreased intraoperative blood loss. However, there remains a discrepancy between the smaller amount of blood loss and higher blood transfusion during hypotensive anaesthesia that calls for further evaluation of our blood transfusion practices to reduce unnecessary blood transfusions.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Lin S, Chen C, Yao YA, Chen YR. Comparison of different hypotensive anaesthesia techniques in orthognathic surgery with regard to intraoperative blood loss, quality of the surgical field, and postoperative nausea and vomiting. Int J Oral Maxillofac Surg 2016;45:1526-30.
2. Prasant MC, Kar S, Rastogi S, Hada P, Ali FM, Mudhol A. Comparative study of blood loss, quality of surgical field and duration of surgery in maxillofacial cases with and without hypotensive anesthesia. J Int Oral Health 2014;6:18-21.
3. Barak M, Yoav L, Abu el-Naaj I. Hypotensive anesthesia versus normotensive anesthesia during major maxillofacial surgery: A review of the literature. Scientific World Journal 2015;2015:480728.
4. Sahu S, H, Verma A. Adverse events related to blood transfusion. Indian J Anaesth 2014;58:543-51.
5. Kouz K, Hoppe P, Briesenick L, Saugel B. Intraoperative hypotension: Pathophysiology, clinical relevance, and therapeutic approaches. Indian J Anaesth 2020;64:90-6.
6. Dahan A, Engberts DP, Niesters M. Arterial line placement: Safety first. Anesthesiology 2016;124:528–9.
7. Lewis PS, on behalf of the British and Irish Hypertension Society's Blood Pressure Measurement Working Party. Oscillometric measurement of blood pressure: A simplified explanation. A technical note on behalf of the British and Irish Hypertension Society. J Hum Hypertension 2019;33:349–51.
8. Pickering TG, Hall JE, Appe l LJ, Falkner BE, Graves J, Hill MN, *et al*. Recommendations for blood pressure measurement in humans and experimental animals: Part 1: Blood pressure measurement in humans: A statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Circulation 2005;111:697-716
9. Kim S-H, Lilot M, Sidhu KS, Rinehart J, Yu Z, Canales C, *et al*. Accuracy and precision of continuous noninvasive arterial pressure monitoring compared with invasive arterial pressure: A systematic review and meta-analysis. Anesthesiology 2014;120:1080–97.
10. Matsuura N, Okamura T, Ide S, Ichinohe T. Remifentanil reduces blood loss during orthognathic surgery. Anaesth Prog 2017;64:3-7.
11. Thastum M, Andersen K, Rude K, Norholt SE, Blomlof J. Factors influencing intraoperative blood loss in orthognathic surgery. Int J Oral Maxillofac Surg 2016;45:1070-3.

12. Nooh N, Abdelhalim AA, Abdullah WA, Sheta SA. Effect of remifentanil on the hemodynamic resposnes and recovery profile of patients undergoing single jaw orthognathic surgery. Int J Oral Maxilofac Surg 2013;42:988-93.
13. Koshika K, Ichinohe T, Kaneko Y. Dose-dependent remifentanil decreases oral tissue blood flow during sevoflurane and propofol anaesthesia in rabbits. J Oral Maxillofac Surg 2011;69:2128-34.
14. Rossi A, Falzetti G, Donati A, Orsetti G, Pelaia P. Desflurane versus sevoflurane to reduce blood loss in maxillofacial surgery. J Oral Maxillofac Surg 2010;65:1007-12.
15. Lin S, McKenna SJ, Yao CF, Chen YR, Chen C. Effects of hypotensive anaesthesia on reducing intraoperative blood loss, duration of operation, and quality of surgical field during orthognathic surgery: A systematic review and meta-analysis of randomized controlled trials. J Oral Maxillofac Surg 2017;75:73-86.
16. Ervens J, Marks C, Hechler M, Plath T, Hansen D, Hoffmeister B. Effect of induced hypotensive anaesthesia vs isovolaemic haemodilution on blood loss and transfusion requirements in orthognathic surgery: A prospective, single-blinded, randomized, controlled clinical study. Int J Oral Maxillofac Surg 2010;39:1168-74.
17. Felfernig-Boehm D, Salat A, Kinstner C, Fleck T, Felfernig M, Kimberger O, *et al*. Influence of hypotensive and normotensive anaesthesia on platelet aggregability and hemostatic markers in orthognathic surgery. Thrombosis Res 2001;103:185-92.
18. Choudhary P, Dutta A, Sethi N, Sood J, Rai D, Gupta M. Pre-induction fentanyl dose-finding study for controlled hypotension during functional endoscopic sinus surgery. Indian J Anaesth 2019;63:653-9.
19. Chhabra A, Saini P, Sharma K, Chaudhary N, Singh A, Gupta S. Controlled hypotension for FESS: A randomised double-blinded comparison of magnesium sulphate and dexmedetomidine. Indian J Anaesth 2020;64:24-30.