Intra-operative blood loss and operating time in orthognathic surgery using induced hypotensive general anaesthesia: prospective study

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We investigated the average operating time and extent of intra-operative blood loss in orthognathic surgeries performed using induced hypotensive general anaesthesia, with the intention of devising a practical guideline for blood unit preparation for these procedures. We prospectively studied 32 Chinese patients undergoing surgery to correct dentofacial deformities at a public hospital in Hong Kong from 1 December 1997 to 1 December 1998. Most patients (72.4%) needed double-jaw surgery. The mean estimated blood loss was approximately 617.6 mL. The blood loss during simple Le Fort I osteotomies was about half that of multiple segmentalised osteotomies. For mandibular ramus osteotomies, the mean blood loss and operating time were approximately 280 mL and 2 hours, respectively; for anterior mandibular osteotomies, the corresponding values were 171.3 mL and 1 hour 13 minutes. The average drop in the haematocrit value was 15.4%, and the crossmatch to transfusion ratio was 29. A bivariate correlation test between the blood loss and operating time gave 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, and a 'type, screen, and save' policy for blood unit preparation is more appropriate than a 'crossmatch' policy.

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Introduction

Maxillofacial orthognathic surgery is widely practised globally, and it is well established because of its capacity to correct many dentofacial deformities. Although surgical precision is important, clinicians should also pay attention to other parameters such as the operating time and intra-operative blood loss.

All parties involved in the surgery—the maxillofacial surgeons, anaesthesiologist, and patient—are interested in the expected operating time and anticipated need for homologous transfusion. A more accurate prediction of operating time and blood loss could help the surgeon and anaesthesiologist improve perioperative management. Guidelines should be drawn up for the crossmatching of blood units to prepare for elective orthognathic procedures. Patients would then be better informed about the likelihood of a transfusion occurring before they undergo the surgery.

Achieving satisfactory haemostasis during orthognathic surgery is difficult because of the extensive vascularity of the maxillofacial region. The need for transfusion could be reduced by using acute normovolaemic haemodilution, controlled moderate hypotension, a cell-saving device, predeposit of autologous blood, and preoperative administration of human recombinant erythropoietin. Although Enlund et al[1] found that induced hypotension may decrease the bleeding rate in orthognathic surgery, they concluded

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that it is not a crucial factor. Many studies, however, have confirmed the positive role of hypotensive general anaesthesia in providing a clear operative field, decreasing operating time, and hence obviating the need for blood transfusion.[2-6] As reported by Schaberg et al,[7] the loss in whole blood volume can be reduced by 40% to 50% when hypotensive anaesthesia is administered. In practice, hypotension is commonly induced to alter regional tissue perfusion through the use of systemic vasodilators, ganglionic blocking agents, and the positioning of the patient. Close anaesthetic monitoring during surgery and communication between the surgeon and anaesthesiologist could permit a safer anaesthesia, shorter operating time, decreased intra-operative blood loss, and a reduced chance of blood transfusion.

Methods

A prospective study was undertaken, involving all patients who were admitted for orthognathic surgery at the United Christian Hospital from 1 December 1997 to 1 December 1998. The study population consisted of 32 Chinese patients, 29 of whom were physical status I, according to the classification system of the American Society of Anesthesiologists (ASA),[8] with no underlying medical problems. Three patients had a thalassaemic trait, which might have influenced their intra-operative anaesthetic management and they were thus excluded in this study.

Data from the demographic information, operating time, intra-operative estimated blood loss (EBL) for each orthognathic procedure, mean arterial pressure (MAP), mean heart rate, and blood transfusion were recorded. Surgery was performed using the same anaesthesia and surgical protocols, and all operations were performed by the same surgical team; hence, differences in results due to variations in surgical technique were believed to be minimal. Although the techniques used to achieve an intentional hypotensive general anaesthesia varied between anaesthesiologists, the MAP was maintained at approximately 70 mm Hg, with a range from 50 to 80 mm Hg. This pressure was reached by increasing the concentration of isoflurane to a maximum end-tidal concentration of 1.5%. If isoflurane alone were insufficient to reduce the MAP to 70 mm Hg, boluses of labetalol hydrochloride 5 mg were added every 5 to 10 minutes to achieve the desired effect.

The orthognathic procedures performed included Le Fort I osteotomies, which comprised a simple osteotomy cut (one or two pieces cut) and multiple segmentalised cut (three or four pieces cut); anterior maxillary segmental osteotomy; mandibular ramus osteotomies, such as bilateral sagittal split osteotomies and vertical subsigmoid osteotomies; and anterior mandibular osteotomies, which included Hofer's osteotomy and genioplasty.

The operating time was calculated for each type of orthognathic procedure as the duration from the start time, when local anaesthetic solution was injected, to the end time, when the oral mucosal wound was closed. The intra-operative EBL for each procedure was calculated by weighing the surgical gauze swabs and measuring the contents of the suction bottle (with adjustment made for the amount of saline irrigation used).

The haemoglobin level and haematocrit value (packed-cell volume) were obtained on the preoperative day and first postoperative day. Surgical procedures were categorised as either maxillary or mandibular and were further subdivided for the analysis. All data were analysed using the Statistical Package for Social Science (Windows version 8.0; SPSS Inc., Chicago, United States). The two-tailed Pearson correlation test was used to assess the bivariate correlation between EBL and operating time, and the change of haematocrit value. A probability level of $P<0.05$ was accepted as being significant.

Results

Nine men and 20 women were involved in the study (male to female ratio, 1:2.2). The mean age was 22.6 years (standard deviation [SD], 4.1 years; range, 16-30 years); the mean (SD) ages of the male and female patients were 20.2 (4.5) years and 24.4 (4.5) years, respectively. The mean preoperative haemoglobin level for the men was 142.6 (14.9) g/L, and for the women it was 123.7 (5.6) g/L (normal ranges, 140-180 g/L and 115-155 g/L for men and women, respectively). No patient was excluded because of contra-indications to hypotensive anaesthesia, such as ischaemic heart disease, hypertension, peripheral vascular disease, cerebral vascular disease, or other severe systemic illnesses (eg renal insufficiency). Although induced hypotensive general anaesthesia was used in all cases with a controlled MAP of 50 to 80 mm Hg, no patient had anaesthetic complications because of this drop in blood pressure, and all patients had uneventful recoveries following the operation.

The majority of patients (72.4%) needed double-jaw surgery (ie bimaxillary surgeries on the maxilla and mandible) with the remainder having single-jaw surgery (ie surgeries on either the maxilla or mandible alone). A total of 61 orthognathic procedures were performed, with 39 being in the mandible and 22 in the maxilla. The types of surgical procedures performed are shown in Tables 1 and 2. Le Fort I osteotomies were used to correct maxillary deformities (n=18), whereas mandibular ramus surgery was used to repair mandibular dentofacial deformities (n=22). Although the operating time for a multiple segmentalised Le Fort I osteotomy was 30% longer than that for a simple Le Fort I osteotomy, the average EBL for the segmentalised procedure was almost twice that of a simple Le Fort I osteotomy (Table 1). The longest operating time (almost 5 hours) and greatest blood loss was associated with double-jaw surgery (Table 3).

According to Messmer,[9] it is not essential, or even desirable, to replace all blood lost in adult patients with normal cardiopulmonary function because they can compensate by homeostasis for a blood loss of up to 20% (approximately 1100 mL) of their circulating blood volume. Hence, the blood loss that resulted from a double-jaw surgery (751.4 [SD, 416.5] mL) was believed to be within this physiological boundary and a blood transfusion was considered as unnecessary. Only one patient needed an intra-operative transfusion of two units of packed cells. The EBL in this case was 2095 mL, and the operating time of 470 minutes was 3 hours longer than the overall mean operating time. Although hypotensive anaesthesia was employed throughout this double-jaw surgery, the bone was very vascularised and bled excessively.

A fall in the haematocrit value was anticipated following orthognathic surgery. The mean drop in haematocrit value on postoperative day 1 was 15.4%. The mean (SD) haematocrit value on postoperative day 1 was 0.34% (0.05%) for single-jaw osteotomies and 0.33% (0.05%) for double-jaw osteotomies. Results from the two-tailed Pearson correlation test showed a strong correlation between intra-operative blood loss and operating time ($P<0.01$). In addition, intra-operative blood loss also correlated strongly with any postoperative drop in haematocrit value ($P<0.01$).

Table 1. Types of maxillary orthognathic surgery performed

	No.	Mean (SD) blood loss (mL)	Mean (SD) operating time (min)
Simple Le Fort I osteotomy (one or two pieces)	10	347.5 (84.4)	160.7 (24.5)
Multiple segmentalised Le Fort I osteotomy (three or four pieces)	8	666.9 (405.0)	210.3 (33.1)
Anterior segmental osteotomy	4	250 (304.1)	118.3 (17.6)

Table 2. Types of mandibular orthognathic surgery performed

	No.	Mean (SD) blood loss (mL)	Mean (SD) operating time (min)
Mandibular ramus surgery			
bilateral sagittal split and vertical subsigmoid osteotomies	22	284.4 (167.0)	127.4 (31.7)
Anterior mandibular osteotomy			
Hofer's osteotomy	5	187.5 (154.8)	102.0 (47.2)
genioplasty	12	164.5 (106.6)	60.8 (32.8)
overall	17	171.3 (104.9)	72.9 (37.4)

Table 3. Operating time, estimated blood loss, and perioperative haematological data for patients undergoing single- and double-jaw osteotomies

	Single-jaw osteotomy, n=8		Double-jaw osteotomy, n=21		Total, n=29	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
Haemoglobin (g/L)						
mean (SD)	127.0 (6.1)	112.0 (16.0)	134.0 (13.0)	112.0 (18.0)	132.0 (12.1)	111.9 (17.8)
range	120.0-140.0	82.0-131.0	111.0-157.0	85.0-156.0	111.0-157.0	82.0-156.0
Haematocrit (%)						
mean (SD)	0.38 (0.02)	0.34 (0.05)	0.40 (0.04)	0.33 (0.05)	0.39 (0.04)	0.33 (0.05)
range	0.35-0.41	0.26-0.40	0.32-0.46	0.25-0.45	0.32-0.46	0.25-0.45
Operating time (min)						
mean (SD)	169.9 (54.3)		296.4 (64.6)		269.0 (77.6)	
range	150.0-330.0		180.0-470.0		150.0-470.0	
Estimated blood loss (mL)						
mean (SD)	266.3 (219.8)		751.4 (416.5)		617.6 (438.9)	
range	50.0-650.0		200.0-2095.0		50.0-2095.0	

As is common practice with other surgical procedures, two units of blood were crossmatched for every patient before their orthognathic surgery.[10] Although this clinical practice is routine in many maxillofacial centres, we wanted to evaluate whether or not this practice was justified. Hence, the crossmatch to transfusion (C/T) ratio was calculated, as the total number of blood units crossmatched for each patient divided by the number of units transfused. The C/T ratio in this study was 29.

Discussion

The demographic data of patients shows that more women than men receive orthognathic surgery for the correction of dentofacial deformities. The female to male ratio (2.2:1) is greater than that (1.8:1) reported by Samman et al.[11] Osteotomy procedures performed on either jaw were equally common. Many patients underwent Le Fort I osteotomies (62%) and mandibular ramus osteotomies (76% bilateral sagittal split osteotomies and vertical subsigmoid osteotomies).

Although this study was not a controlled trial that randomised patients into different surgical groups to test the effect of induced hypotensive general anaesthesia on blood loss and operating time, the results are comparable to some international studies. The mean (SD) operating time in this study was 269.0 (77.6) minutes, which is similar to the time (217.1 minutes) obtained by Washburn and Hyer.[12] The mean (SD) EBL in this study was 617.6 (438.9) mL, which is comparable to the figures obtained by Schaberg et al[7] when they performed oral-facial corrective surgery (729 [134] mL) and Samman et al[11] (600 mL). The operating time involved in a multiple segmentalised osteotomy was about twice that of a simple osteotomy. It would thus be beneficial to develop orthognathic surgical plans that would shorten operating times and minimise blood loss. To achieve this, sound preoperative surgical analysis and experienced orthodontic support staff would be needed.

Controlled moderate hypotension reduces the rate of surgical bleeding. An early blood-volume study that compared maxillofacial surgical patients with normotensive versus hypotensive management during general anaesthesia, showed that the mean (SD) MAP dropped from 89.94 (2.13) mm Hg to 72.79 (1.63) mm Hg. Furthermore, hypotensive general anaesthesia brought about a 40% reduction in the volume of whole blood lost and a 44% reduction in the volume of red blood cells lost, compared with when normotensive general anaesthesia was used.[7] Many studies[2-7,12-14] show a significant reduction in the need for homologous transfusion when anaesthetic methods that induce moderate hypotension and a lowered MAP are used.

The results from this study suggest that intentional hypotensive general anaesthesia is safe and enables good control of blood loss in young healthy adult patients undergoing elective orthognathic surgery. All patients should be carefully assessed before surgery for any contra-indications to hypotensive anaesthesia. The technique has the potential to lessen major blood loss, produce a drier surgical field, and decrease operating time. Schindler et al[13] induced moderate hypotension when they performed maxillofacial surgery and found that, with the exception of the first 30 minutes of the operation, an average systolic arterial pressure of 89 mm Hg and a MAP of 65 mm Hg produced satisfactory operating conditions. Hence, we decided to maintain patients' MAPs at 70 mm Hg (range, 50-80 mm Hg) to optimise operating conditions.

The optimal haematocrit value is determined by the oxygen-carrying capacity of blood and its fluidity in the absence of hypoxia. According to Messmer[9] and Fordyce et al,[14] normovolaemic patients who have normal compensatory mechanisms should be able to tolerate values as low as 0.27% to 0.30%. This study showed that the overall haematocrit value dropped from 0.39% to 0.33%, which is higher than the established tolerable range.

There are circumstances in which homologous blood will probably be required in elective surgery. In these cases, the 'crossmatch' or 'type, screen, and save' (TSS) procedures can be used. The transfusion index (TI) is the mean number of blood units transfused per surgical procedure, and a TI of 0.5 has been used as the cut-off to decide when to implement the crossmatch (TI>0.5) and TSS (TI<0.5) procedures. This study showed that no patient undergoing a single-jaw osteotomy required transfusion (TI=0); only one patient who underwent a double-jaw surgery was transfused (TI=0.047). This transfusion rate was considerably lower than the figure of 24%, which was quoted by Samman et al.[11] Their study, however, included many major or difficult osteotomy procedures.

The C/T ratio is a useful index that reflects the efficiency of blood ordering and usage; a C/T ratio of 2.5 is considered generally acceptable for a full range of surgical procedures. The C/T ratio from this study was 29, which signifies a preoperative overordering of crossmatched blood units for normal adult patients who are about to undergo orthognathic surgery. There should be a minimal need for transfusion in orthognathic surgeries involving a C/T ratio of 29. This shows that the current crossmatching blood policy used at the United Christian Hospital leads to an overestimation of blood needs.

There are currently no conclusive guidelines for blood transfusion in the United Kingdom.[15] The American College of Physicians have published a transfusion guideline in 1992, which addressed the transfusion needs in perioperative settings.[15] According to the original paper on which the guidelines were based, a minimum haemoglobin concentration of at least 70 g/L should be maintained to ensure patient safety. Although tissue oxygenation can be maintained at a haemoglobin level below 100 g/L, the lowest safe haemoglobin concentration is not clearly defined.

The need for crossmatched blood units for orthognathic surgery in healthy individuals with an expected blood loss of less than 500 mL is debatable. It is not essential, or even desirable, to replace all blood lost during the surgery because an adult patient with normal cardiopulmonary function can compensate for up to a 20% loss of circulating blood volume. Physicians have a duty to reduce the amount of blood units wasted and to prepare realistic guidelines on how much blood should be crossmatched for elective orthognathic procedures. The authors of a study that assessed the need for preoperative autologous blood donation in patients undergoing orthognathic surgery noted the low frequency of transfusion in lower-jaw surgery and concluded that the need for blood transfusion is unlikely.[16] Hence, we believe it is unnecessary to crossmatch blood for adult patients of ASA physical status I who are to undergo single- or double-jaw osteotomies. A TTS policy is adequate for these patients.

Conclusion

This study confirms the positive relationship between intra-operative blood loss and the length of operating time when using induced hypotensive general anaesthesia. This information can be used to reassure patients about the amount of blood likely to be lost during surgery and the low rate of transfusion associated with the technique.

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