Oral Maxillofac Surg
DOI 10.1007/s10006-013-0415-4

ORIGINAL ARTICLE

Intraoperative blood loss and blood transfusion requirements in patients undergoing orthognathic surgery

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Received: 30 November 2012 / Accepted: 15 April 2013

Abstract Procedures for the surgical correction of dentofacial deformities may produce important complications, whether due to the potential for vascular injury or to prolonged surgery, both of which may lead to severe blood loss. Fluid replacement with crystalloid, colloid, or even blood products may be required. The aim of this study was to assess blood loss and transfusion requirements in 45 patients (18 males and 27 females; mean age 29.29 years, range 16–52 years) undergoing orthognathic surgery, assigned to one of two groups according to procedure type—rapid maxillary expansion or double-jaw orthognathic surgery. Preoperative hemoglobin and hematocrit levels and intraoperative blood loss were measured. There was a substantial individual variation in pre- and postoperative hemoglobin values (10.3–17 and 8.8–15.4 g/dL, respectively; $p<0.05$). Mean hematocrit values were 41.53 % preoperatively (range 31.3–50.0 %) and 36.56 % postoperatively (range 25–43.8 %) ($p<0.05$). Mean blood loss was 274.60 mL (range 45–855 mL). Only two patients required blood transfusion. Although blood loss and transfusion requirements were minimal in the present study, surgical teams should monitor the duration of surgery and follow meticulous protocols to minimize the risks.

Keywords Blood loss · Hypovolemic · Hematocrit · Blood transfusion

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Introduction

Surgical approaches to the correction of dentofacial deformities are complex procedures that have proven effectiveness in reestablishing oral function and achieving facial harmony; however, complications may arise. Blood loss, for example, has a profound impact on postoperative morbidity and mortality after orthognathic surgery and is considered one of the major complications of this type of procedure. Some studies have reported blood losses of up to 1,575 mL [18] requiring fluid replacement with crystalloids, colloids, or blood products.

Blood transfusion during intraoperative blood loss and the possibility of performing the procedure under induced/controlled hypotension should be considered [4, 12]. Cardiac output and vascular resistance are the only parameters that can be altered with no real change in blood volume. Induced hypotension thus allows procedures to be performed with lower heart rates, decreased blood loss, improved visualization of the surgical field, and hence significantly reduced operating time [2].

Published online: 26 April 2013

Orthognathic surgery for the correction of facial deformities may be associated with significant bleeding. Hence, hypotensive anesthesia is often used to reduce blood loss [27, 28]. Hypotensive anesthesia methods are established and effective means of curtailing intraoperative bleeding and are used particularly in orthognathic surgery; reductions in intraoperative blood loss of up to 40 % have been reported with the use of hypotensive techniques [23].

Another key factor during hypotensive anesthesia is autoregulation of cerebral blood flow, which allows adequate flow to be maintained with mean arterial pressures of 50–150 mmHg. When the mean arterial pressure falls below 50 mmHg, these autoregulation mechanisms fail, and cerebral blood flow decreases in a linear fashion; irreversible neurologic damage may follow [2].

The American College of Surgeons Committee on Trauma has established a four-stage classification of hypovolemic shock based on the severity of volume loss, giving appropriate recommendations for fluid resuscitation. In this staging system, class I corresponds to a blood volume loss of up to 15 %, which is reflected clinically as moderate tachycardia without hypotension or increased respiratory rate. Class II corresponds to 15–30 % blood volume loss; class III, 30–40 %; and class IV, to loss greater than 40 % of total blood volume. As hypovolemia progresses, clinical signs such as tachycardia, hypotension, and tachypnea worsen, culminating in a decreased level of consciousness and circulatory collapse. The severity of hypovolemic shock must therefore be established to allow correct restoration of oxygen transport and maintenance of cardiac output with fluid resuscitation, using crystalloids, colloids, or even blood transfusion [1, 21, 24–26].

In a 6-year retrospective study on over 400 Le Fort I osteotomies, bleeding-related complications were reported in three cases. Significant postoperative blood loss occurred in those cases, mostly associated with injuries to the descending palatine artery, pterygoid plexus, and greater palatine artery. Initial treatment consisted of anterior and posterior nasal cavity packing. However, whenever bleeding could not be contained, a more invasive approach was adopted, with embolization of the maxillary artery or, in particularly severe cases, external carotid artery ligation [13]. Recent papers showed that just few cases require blood replacement in orthognathic surgery [14, 19].

The present study is justified in raising awareness of fluid replacement practices among oral and maxillofacial surgeons and anesthesiologists, as the current literature is controversial and ambiguous in this respect. There is a dearth of studies investigating blood loss and fluid replacement in orthognathic surgery (bimaxillary) and surgically assisted rapid maxillary expansion.

Therefore, the objectives of this study were to evaluate blood loss and transfusion requirements by comparing Hb and Hct values and by quantitatively assessing intraoperative blood loss and to investigate whether a correlation exists between these factors and gender, age, type of procedure, choice of fluid replacement method, and efficacy of anesthetic technique.

Materials and methods

The study sample comprised patients submitted to orthognathic surgery or rapid maxillary expansion at a Bauru Hospital Association between March 2011 and March 2012.

Patients were divided into two groups depending on procedure: group 1, surgically assisted rapid maxillary expansion and group 2, double-jaw (bimaxillary) orthognathic surgery.

After preanesthetic assessment and evaluation of surgical risk, healthy patients—those in categories 1 and 2 of the physical status classification system of the American Society of Anesthesiologists (ASA) and with no systemic disease that could entail increased surgical risk—were selected for inclusion in the study.

Prior to anesthesia induction, blood samples were collected for Hb and Hct measurements. This procedure was repeated shortly after extubation, for determination of postoperative Hb and Hct levels. Blood loss was measured by weighing sterile cotton gauze pads (7.5×7.5 cm) (Cremer®, São Paulo, Brazil) and sponges (50×40 cm) (Cremer®, São Paulo, Brazil) used during the procedure as well the blood loss in the gauze oropharyngeal pack, and mostly by analysis of aspirated blood volume, as irrigation of the surgical field with normal saline is a common practice in orthognathic surgery so as to permit improved visualization of anatomical structures. Gauze pads and sponges were weighed on precision scales (Arja®, São Paulo, Brazil), and the previously established tare weight was subtracted to allow calculation of soaked blood volume. Saline use was also strictly controlled so that saline volume could be subtracted from the total volume of aspirated fluid at the end of the procedure. All values were then added to produce the total blood volume lost during surgery.

The surgery was performed with blood pressure control by means of hypotensive anesthesia. One tablet of 15 mg midazolam was prescribed for the patient preoperatively, and after 30 min, the patient was taken to the surgery room where the anesthesiologist proceeded with general anesthesia with the combination of intravenous anesthetic (propofol), inhaled (oxide nitrous), and muscle relaxants (atracurium). Blood pressure was controlled during the procedure with the increase, if necessary, intravenous and inhaled anesthetic. If blood pressure value still continued to increase, intravenous antihypertensive drugs could be used.

Gender, age, and clinical characteristics were entered into specially designed charts. After collection, data were expressed as means and standard deviation and were organized into tables and charts as relevant. The Student's t test was used for comparisons between genders, ASA physical status (ASA PS) classifications, and groups. The paired t test was used for comparisons between pre- and postoperative Hb and Hct values. Pearson's correlation coefficient was used to evaluate the correlation between age and other variables.

Statistical analyses were performed using the Statistical Package for the Social Sciences®, version 13.0 (SPSS, Inc., IBM, Chicago, IL, USA). The significant level was set at 0.05.

Results

Of the 45 patients included in the study, 18 (40 %) were male, and 27 (60 %) were female. With respect to the ASA classification, 37 patients (82.2 %) were ASA PS 1, and the remaining 8 (17.8 %) were ASA PS 2. Thirty patients (66.6 %) underwent surgically assisted rapid maxillary expansion (group 1), and 15 (33.4 %) underwent bimaxillary osteotomy (group 2).

Mean patient age was 29.29 years (range 16–52 years). There was considerable individual variation in both the pre- and postoperative Hb values (range 10.3–17 and 8.8–15.4 g/dL, respectively). Mean pre- and postoperative Hct levels were 41.53 % (range 31.3–50.0 %) and 36.56 % (range 25–43.8 %), respectively. Mean, minimum, and maximum blood volumes lost were 274.60, 45, and 855 mL, respectively (Table 1).

Differences between pre- and postoperative Hb and Hct levels were statistically significant ($p<0.05$). Nonetheless, blood transfusion was indicated in one patient (Table 2).

Analysis of possible gender-related changes showed that both pre- and postoperative mean Hb and Hct values were prevalent in male and female patients. No statistically significant gender differences were found between pre- and postoperative Hb and Hct changes (−1.48 vs. −1.9 and −4.61 vs. −5.59 in females and males, respectively), justifying the lack of gender differences in fluid replacement. Mean blood loss was also statistically similar in female and male patients (250.70 vs. 314.44 mL, respectively) (Table 3).

Table 1 Variables assessed in the study sample (n=45)

Parameter	Mean	SD	Min	Max
Age (years)	29.29	8.95	16.0	52.0
Pre-op Hb	14.05	1.35	10.3	17.0
Post-op Hb	12.41	1.38	8.8	15.4
Hb change	−1.64	1.23	−4.8	0.9
Pre-op Hct	41.53	4.08	31.3	50.0
Post-op Hct	36.56	3.71	25.0	43.8
Hct change	−4.98	3.44	−14.7	2.6
Blood loss	274.60	197.85	45.0	855.0

SD standard deviation, Hb hemoglobin, Hct hematocrit

Table 2 Comparison of pre- and postoperative Hb and Hct values

	Pre-op		Post-op			
Parameter	Mean	SD	Mean	SD	t	p
Hb	14.05	1.35	12.41	1.38	9.192	<0.001*
Hct	41.53	4.08	36.56	3.71	10.021	<0.001*

Hb hemoglobin, Hct hematocrit, SD standard deviation

*$p<0.05$ (statistically significant difference)

Comparison of patients according to ASA classification showed no statistically significant differences in preoperative Hb (14 g/dL in ASA PS 1 patients and 14.26 g/dL in ASA PS 2), postoperative Hb (12.38 g/dL in ASA PS 1 patients and 12.55 g/dL in ASA PS 2 patients), preoperative Hct (41.34 % in ASA PS 1 patients and 42.49 % in ASA PS 2), postoperative Hct (36.52 % in ASA PS 1 patients and 36.74 % in ASA PS 2), or mean blood loss (285.88 mL in ASA PS 1 patients and 218.25 mL in ASA PS 2 patients). Differences between the pre- and postoperative Hb and Hct were also similar in both ASA status groups (Table 4). There were no significant intergroup differences in preoperative Hb values (13.86 and 14.51 g/dL in groups 1 and 2, respectively) or preoperative Hct levels (12.52 and 12.35 g/dL, respectively). Conversely, pre- to postoperative changes in Hb levels in group 2 were significantly different from those found in group 1. The preoperative Hct values were relevant as was the variation between the pre- and postoperative Hct, but there were no statistically significant differences between the groups in postoperative Hct values (Table 5).

Differences in blood loss were also statistically significant—mean blood loss was 453.33 mL in group 2 and 188.03 mL in group 1 ($p<0.05$) (Table 5).

Pearson's correlation coefficient showed no relation between patient age and any other variables of analysis (pre- and postoperative Hb and Hct, and blood loss).

Discussion

No statistically significant gender differences were found in the intraoperative blood losses and pre- to postoperative Hb and Hct changes, showing an absence of correlation between gender, severity of hypovolemia, and transfusion requirements. These results are consistent with those reported in all studies included in our literature review, which have suggested that blood loss

Table 3 Comparison of parameters by gender

Parameter	Female		Male		t	p
	Mean	SD	Mean	SD		
Pre-op Hb	13.43	1.04	15.07	1.18	−5.041	<0.001*
Post-op Hb	11.95	1.16	13.17	1.40	−3.258	0.002*
Hb change	−1.48	1.20	−1.90	1.28	1.156	0.254
Pre-op Hct	39.80	3.22	44.42	3.77	−4.514	<0.001*
Post-op Hct	35.19	3.25	38.83	3.38	−3.700	0.001*
Hct change	−4.61	3.47	−5.59	3.40	0.962	0.341
Blood loss	250.70	199.34	314.44	194.29	−1.083	0.285

Hb hemoglobin, Hct hematocrit, SD standard deviation

*p<0.05 (statistically significant difference)

is associated with procedure type and duration of surgery, not with patient gender [3, 11, 18, 22].

The present study was conducted on a sample of young adult patients (age, 16–52 years). Both Student's t test and Pearson's correlation coefficient failed to show any statistically significant age-related difference in Hb, Hct, and blood loss parameters; again, this finding is consistent with that in the literature [2, 15]. This is explained by the fact that blood loss is mostly associated with coagulopathies and other systemic disorders and does not correlate with patient age.

While surgically assisted rapid maxillary expansion has not been mentioned in previous investigations on blood loss in orofacial corrective surgery, the present study assessed 27 patients undergoing this type of surgery (group 1) and confirmed that transfusion is unnecessary. A single patient experienced major blood loss secondary to intraoperative hemorrhage of the pterygoid plexus. Normovolemia was reestablished after infusion of 2 units of packed red blood cells, and the postoperative course was uneventful.

Orthognathic surgery has long been regarded as potentially producing major blood loss and reduction in blood volume. Many authors find major blood loss to be particularly associated with double-jaw surgery with interpositional bone grafting [11, 20, 22], while others associate it with the complexity and prolonged duration of these procedures [5, 8, 9, 15]. Conversely, the patients in group 2 of the present study experienced no major blood losses. Only one patient had hypovolemia with reduction in Hb and Hct values and was successfully resuscitated with crystalloid fluids in the postoperative period. These findings may suggest that when meticulous surgical techniques are followed and procedure times are kept brief, blood loss and transfusion requirements in bimaxillary orthognathic surgery are unlikely to occur.

The consensus found in the literature reviewed for the present study is that orthognathic surgery should be performed under general hypotensive anesthesia, induced with adequate preanesthetic agents, and maintained with a combination of intravenous and inhalational agents in order to maintain reduced cardiac output and vascular resistance, ensuring a bloodless surgical field and, consequently, decreased blood loss and duration of surgery [2–6, 10, 12, 14, 18, 23]. This consensus is corroborated by the findings of the present study—the association of anesthetic medications provided improved visualization of the surgical field, whereas the reduced procedure times and improved surgical techniques yielded decreased blood volume loss and transfusion requirements.

A drug widely used especially in cardiac and orthopedic surgery to reduce bleeding during the surgical act is tranexamic acid. In this aspect, Choi et al. [3] evaluated the efficacy of tranexamic acid in 63 patients who underwent bimaxillary orthognathic surgery under hypotensive anesthetic. The test group showed a

Table 4 Comparison of parameters by ASA classification

Parameter	I		II		t	p
	Mean	SD	Mean	SD		
Pre-op Hb	14.00	1.32	14.26	1.57	−0.494	0.623 (NS)
Post-op Hb	12.38	1.47	12.55	0.83	−0.311	0.757 (NS)
Hb change	−1.62	1.25	−1.71	1.19	0.192	0.849 (NS)
Pre-op Hct	41.34	4.00	42.49	4.62	−0.721	0.475 (NS)
Post-op Hct	36.52	3.94	36.74	2.42	−0.150	0.882 (NS)
Hct change	−4.82	3.47	−5.75	3.41	0.692	0.492 (NS)
Blood loss	285.88	208.15	218.25	130.63	0.880	0.383 (NS)

Hb hemoglobin, Hct hematocrit, NS nonsignificant, SD standard deviation

Table 5 Comparison between groups 1 and 2

Parameter	G1		G2		t	p
	Mean	SD	Mean	SD		
Pre-op Hb	13.86	1.39	14.51	1.22	−1.549	0.129
Post-op Hb	12.52	1.47	12.35	1.22	0.386	0.701
Hb change	−1.34	1.24	−2.17	0.87	2.293	0.027*
Pre-op Hct	40.74	4.10	43.37	3.79	−2.083	0.043*
Post-op Hct	36.50	4.01	36.71	3.55	−0.169	0.867
Hct change	−4.24	3.74	−6.67	2.39	2.284	0.027*
Blood loss	188.03	157.97	453.33	168.53	−5.195	<0.001*

Hb hemoglobin, Hct hematocrit, SD standard deviation

*$p<0.05$ (statistically significant difference)

significant reduction in trans-operative bleeding, with an average of 422 mL of blood superiorly where acid was not applied. Therefore, the use of this medication in bimaxillary osteotomies is favorable for the reduction of hypovolemia and necessity of blood transfusion. In this study, patients were not administered with tranexamic acid for not being part of the working philosophy of the anesthesiology team, getting hypotensive anesthesia with the combination of anesthetics drugs as mentioned earlier. However, we recognize the importance of this drug.

When fluid replacement is required, some reports have suggested the use of blood transfusion, particularly in bimaxillary and otherwise time-consuming procedures [11, 22] and in those in which autologous bone graft harvesting is performed simultaneously [16, 20]. However, indication of blood replacement is rare and should be based not only on laboratory parameters (primarily, reduced Hb and Hct levels) but also on clinical signs indicative of a true need for transfusion, such as tachycardia, tremor, diaphoresis, and malaise. This practice is consistent with the present study, in which transfusion was indicated in only one patient, whose symptoms suggested a need for resuscitation with blood products.

Moreover, the present study further agrees with the literature that, when required, fluid replacement can be achieved with the administration of crystalloid fluids, particularly lactated Ringer's solution, which has a similar composition to plasma [2, 7, 9, 15, 17].

Conclusion

In conclusion, in our sample, there were no gender- or age-related differences in Hb and Hct levels, blood loss, and need for transfusion. Blood loss was greater in patients undergoing double-jaw orthognathic surgery (group 2) than in those undergoing rapid maxillary expansion (group 1). In the present study, blood loss and transfusion requirements during orthognathic surgery were minimal

Conflict of interest None.

Ethical approval The study protocol was approved by the Research Ethics Committee at Araçatuba Dental School, Universidade Estadual Paulista (UNESP) (protocol no. 2008–02413).

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