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Alternative methods for reduction of blood loss during elective orthognathic surgery

Bimaxillary orthognathic surgery and genioplasty are frequently performed to correct dentoskeletal anomalies in otherwise healthy young patients. Until 1990 homologous blood transfusions were routinely necessary for these procedures. The present study describes a protocol of blood-saving measures that was adopted and tested on a continuous sample of 127 patients treated between 1994 and 1997. The protocol comprises acute normovolemic hemodilution, controlled moderate hypotension, positioning the surgical field above the heart level, cell saving, intraoperative homeostasis, preoperative autologous blood donation, administration of recombinant erythropoietin, and acceptance of a low hematocrit perioperatively. This study shows that homologous blood transfusions may be avoided intraoperatively by following the protocol described. (Int J Adult Orthod Orthognath Surg 1999;14:77–82)

Bimaxillary orthognathic intervention is an accepted therapeutic measure to correct hereditary and acquired dentoskeletal deformity. The surgical procedure is standardized and yields predictable, stable results. Nevertheless, the procedure is invasive and may regularly be associated with the loss of more than 500 mL of blood.[1–6] Proficient bleeding control in the surgical field by the surgeon and the surgical team alone is not possible. Until the end of the 1980s, homologous blood transfusions were routinely necessary in such procedures because of the large amounts of blood lost during surgery.

Steps are taken to avoid transfusing homologous blood because of the risks involved and because of the limited number of available homologous blood preparations. The risks incurred when transfusing homologous blood include transmission of bacterial, viral, or protozoal infections as well as alloimmunization. Furthermore, an accompanying immunosuppression may increase the postoperative infection rate.[7]

The majority of patients undergoing bimaxillary orthognathic surgery are young and generally healthy, and optimized preoperative measures can be made because the procedures are elective. Several blood-saving measures can be undertaken for such patients before, during, and after the operation. Preoperatively, an autologous blood donation may be made and erythropoiesis can be stimulated using recombinant human erythropoietin. Intraoperatively, in addition to an atraumatic surgical approach, several other measures can be taken to reduce blood loss. These include acute normovolemic hemodilution, controlled moderate hypotension, positioning the surgical field above heart level, cell sav-

Table 1 Contraindications and complications of blood-saving measures

Blood-saving measures	Contraindications	Complications
Acute normovolemic hemodilution (ANH)	Anemia, hypovolemia, significant cardiovascular disease, severe respiratory insufficiency, systemic infection, sepsis, fever of unknown origin, hemorrhagic diathesis, hypoalbuminemia	Tissue hypoxia
Controlled moderate hypotension (CMH)	Cerebrovascular insufficiency, coronary heart disease, valvular heart disease, heart insufficiency, elevated intracranial pressure, disturbed function of lung, kidney, and liver, anemia	Irreversible ischemia
Cell saver (CS)	Infected wounds, oncologic procedures	Hemorrhagic diathesis
Preoperative autologous blood donation (PBD)	Same as for ANH	Same as for ANH
Preoperative rh-erythropoietin application (rh-EPO)	Starting hemotocrit ≥ 45%, thrombocytosis, hypertonia	"Influenza-like syndrome"

ing, precise monitoring of balanced homeostasis, and acceptance of a lower hematocrit value.

As part of a quality-control survey of such routine surgical procedures, a prospective clinical study was carried out between June 1994 and May 1997 to assess the reduction of homologous blood transfusions by using a variety of blood-saving measures. The aim of this study was to evaluate how many homologous blood transfusions could be avoided during elective bimaxillary orthognathic surgery by employing standardized blood-saving measures.

Method

The prospective study was accepted by the ethical committee of the University Hospital in Zurich. The clinical study comprised 127 patients who underwent bimaxillary orthognathic procedures between June 1, 1994, and May 31, 1997.

Underlying pathologies for these patients included inherited dentoskeletal deformities and pretreated cleft formations such as prognathia, retrognathia, and maxillomandibular asymmetries. Almost all the patients had preoperative orthodontic treatment to optimize the shape of the dental arches. No orthodontic therapy was needed for those patients who were treated for posttraumatic malocclusion and obstructive sleep apnea syndrome. Patients were excluded if they had craniofacial syndromes (eg, otomandibular dysostosis, M. Crouzon and Apert syndromes, ectodermal dysplasia), compromised general health, impaired hemostasis, or if they required simultaneous bone grafts.

After obtaining informed consent from the patients, a standardized protocol of blood-saving measures was set up when more than 500 mL of blood loss was considered possible. Each specific measure in this protocol is listed in Table 1, giving the relevant contraindications and complications.

Table 2 Biometric data recorded (n = 127)

	Median	Range
Age (y)	19	(15–53)
Body weight (kg)	60	(40–113)
Body height (cm)	169	(147–95)
Gender (male/female)	48/79	
ASA* I/II	114/13	
Preoperative hematocrit (%)	39.6	(28.0–55.7)
Length of surgery (min)	402	(140–630)
Intraoperative blood loss (mL)	1200	(500–3000)
Intraoperative hematocrit (%)	30.5	(20.5–43.0)
Intraoperative body temperature (°C, rectal)	36.4	(35.4–37.2)
Intraoperative MAP (mm Hg)	68	(55–80)
Intraoperative SAP (mm Hg)	100	(85–120)
Intraoperative DAP (mm Hg)	53	(40–65)
Intraoperative heart rate (1/min)	80	(60–100)
Intraoperative arterial O_2 partial pressure (kPa)	24.8	(12.0–46.5)
Intraoperative arterial CO_2 partial pressure (kPa)	4.5	(3.8–5.3)

*ASA classification is a risk scoring system of the American Society of Anesthesiologists.

Protocol

Six weeks prior to surgery, a preoperative autologous blood donation was organized at a suitable organization. If the selection criteria for this procedure were fulfilled, two blood units were taken from each patient.

After starting the general anesthesia, an acute normovolemic hemodilution (ANH) was carried out under invasive monitoring. Considering the patient's condition and the actual hematocrit, a mean blood sample of 9 mL blood/kg body weight was collected, and hydroxyethylic starch was infused to maintain normovolemia.

Patients were positioned on the operating table so that the surgical field was higher than the heart level.

Intraoperatively, a controlled moderate hypotension was maintained pharmacologically, yielding a mean arterial blood pressure of 60 mm Hg. In patients with pre-existing hypertension, the mean arterial pressure was reduced by no more than 20% of the preoperative reading.

Blood aspirated from the surgical field intraoperatively was heparinized and collected in a cell saver reservoir. Sufficient blood samples were subjected to washing processes, centrifuged, and then retransfused (Compact-A, dideco).

Because of the anticipated good results, the following therapy was integrated in the present study in 1995: Beginning 3 weeks prior to surgery, 200 IU human recombinant erythropoietin/kg body weight (rh-EPO) was administered twice weekly up to a hematocrit of 50% instead of using the preoperative autologous blood donation.

Intraoperative homeostasis was stabilized by maintaining the following parameters: heart rate 50 to 110 beats/min, mean arterial pressure 60 to 80 mm Hg, central venous pressure 2 to 12 mm Hg, urine volume ≥ 0.5 to 1.0 mL/kg body weight/h, pulse oximetric O_2 saturation ≥ 97%, arterial pO_2 ≥ 13 kPa, arterial pCO_2: 4.5 to 5.5 kPa, hematocrit ≥ 20%, and a rectal temperature varying between 35.5°C and 36.5°C.

All patients underwent a standardized, predominantly intravenous general anesthesia. Prior to incision, all the patients were given 500 mg methylprednisolone intravenously to reduce edema formation and 40 mg omeprazol to avoid stress ulceration. Cefuroxim or clindamycin was administered to all patients for at least 3 days after considering the contraindications. In addition, a single dose of netilmicin was given to all cell-saver patients 30 minutes before retransfusing the cell-saver blood.

Any blood loss was first treated by infusions of cristalloid and colloidal solutions, controlling the hematocrit closely at a level of 20%, if conditions permitted. The ANH blood samples were retransfused after surgery, and if necessary, the cell-saver erythrocyte suspension was retransfused prior to that.

Results

Biometric and relevant intraoperative data are summarized in Table 2.

No unexpected values occurred intraoperatively in heart rate; systolic, diastolic, and mean arterial pressure; or in arterial O_2 and CO_2 partial pressure; nor were any temperature changes recorded (Table 2). Changes in hematocrit were registered during the recording period because of blood loss during surgery.

Controlled moderate hypotension was induced in all patients included in the present study. Acute normovolemic hemodilution was maintained in 77.2% of the cases, while cell saving was performed in 76.4% of the patients. Preoperative donated blood units were available for 57.5% of the patients, and 15.7% were given rh-EPO preoperatively (Table 3).

Table 3 Distribution of blood-saving measures (n = 127)

Blood-saving methods	No. of patients	%
Preoperative autologous blood donation (PBD)	73	57.5
Preoperative rh-erythropoietin application (rh-EPO)	20	15.7
Cell saver (CS)	97	76.4
Acute normovolemic hemodilution (ANH)	98	77.2
Controlled moderate hypotension (CMH)	127	100.0

None of the 127 patients required homologous blood intraoperatively. Postoperatively, however, 2 of 127 patients received 1 and 2 concentrates of erythrocytes, respectively. The first patient had a subclinically disturbed hemostasis that was detected neither from the patient's history nor from the preoperative screening. In the second patient, the cell-saver preparation could not be retransfused due to a misunderstanding in the team and subsequent loss of the blood sample. Rare patient conditions and human error may indicate a minimal need for banked blood.

Discussion

Several reports have shown that bimaxillary osteotomies associated with blood loss regularly required blood transfusions.[1-4] Samman et al[4] described that 78 of 291 patients (27%) undergoing bimaxillary osteotomy received homologous blood transfusions. In contrast, none of the 127 patients in the present study required banked blood intraoperatively. Consequently, the success of blood-saving measures is obvious.

Autologous blood was collected by means of an acute normovolemic hemodilution (ANH) after inducing general anesthesia in 98 of 127 patients. Retransfusion of high-quality erythrocytes and intact clotting factors was performed at the end of surgery for all patients in the present study. However, the main problem concerning the use of ANH is the degree of hematocrit due to hemodilution. This is influenced by individual systemic conditions. Unfortunately, no consensus of opinion is available for those hematocrit values requiring transfusion. It is generally accepted that maintaining normovolemia is a basic prerequisite for the acceptance of low hematocrit values. Consequently, an adequate continuous invasive monitoring of patients, in particular patients who are cardiopulmonary compromised, should be instituted.

The object was to obtain a controlled moderate hypotension (CMH) with a mean arterial blood pressure of 60 mm Hg in the 127 patients under continuous invasive pressure monitoring. The median of mean arterial pressure for these patients was 68 mm Hg. Several earlier studies[6,8-11] reported a decrease in the amount of blood lost intraoperatively when CMH was used. However, the use of CMH as a single modality should not be overrated. Nevertheless, minimizing the incidences of systolic blood pressure peaks and lowered diastolic pressure plays an important role within the blood-saving measures that lead to a reduced intraoperative blood loss.

In the present sample, the volume of collected blood was large enough in 62 of 127 patients to be processed by a cell-saver system (CS). In such cases, the collected blood was subsequently retransfused. Several researchers suggest that blood aspirated from a bacterially contaminated wound is contraindicated for retransfusion. Some reports recommend the cell saver for transoral procedures.[12] However, our experimental data in terms of a different study in transoral surgery indicate that a retransfusion of cell-saver erythrocyte blood suspension may cause elevated cytokine values and bacterial contamination.

A preoperative autologous blood donation (PBD) was organized for 73 of the 127 patients. Of these 73 patients, 15 received their own blood intraoperatively, while 6 others were retransfused postoperatively in the intermediate care unit. When possible, preoperative autologous blood donations should be accepted as one of the possible blood-saving measures. Undoubtedly, the use of PBD significantly increases the safety margin for patients. However, in the present study the donated blood was retransfused only when all other options had been exhausted because the risks incurred by using PBD (ie, contamination, overstorage, and mismatch) are similar to those associated with banked blood, except that the source is known. Like transfusing banked blood, donation of autologous blood needs careful planning and should be preserved for postoperative hemorrhages.

Since 1995 20 patients in this study were given recombinant human erythropoietin (rh-EPO) during the preoperative phase instead of donating autologous blood. The mean hematocrit 1 day before the operation was 48.1%, and this decreased to 37.3% after surgery by using the blood-saving methods. Only a few minutes were required to administer the rh-EPO using the hospital's infrastructure. Patients seemed more comfortable with this less invasive procedure compared with the more exhausting blood donation. In addition, the rh-EPO administration had the same effect as the PBD. Because rh-EPO is a more expensive procedure, its routine administration will need time to gain acceptance.

In addition to the ANH, CMH, CS, PBD, and rh-EPO methods described, additional blood-saving measures should be considered. Surgical experience with a direct, atraumatic approach plays an important role in such time-consuming operations. The patient should be correctly positioned on the operating table from the onset of the operation, and the surgical field should always be kept above heart level.

An additional major problem during surgery is maintaining the intraoperative homeostasis, which comprises the continuous stability of cardiovascular, pulmonary, and laboratory parameters. Body temperature and fluid balance must also be controlled. However, it may be difficult to estimate the correct amount of intraoperative blood loss for maxillofacial operations.[8,13] As shown in Table 2, the intraoperative homeostasis was adequately maintained, with all 127 patients having normothermia during their operations. According to Valeri et al,[14] hypothermia may frequently lead to hemorrhagic diathesis and elevated blood loss. Besides trying to control the mean arterial pressure, it was also attempted to avoid systolic peaks and low diastolic values. Both entities are known to aggravate blood loss. Furthermore, partial pressures of O_2 and CO_2 were accurately monitored because elevated CO_2 levels may induce a vasodilation, leading to increased blood loss.

This study shows that transfusion of homologous blood is not necessary during bimaxillary orthognathic surgery when specific blood-saving methods are correctly carried out. It was not the intention to set rigid blood-saving measures, but to suggest appropriate and individualized methods to reduce intraoperative blood loss during elective orthognathic surgery. This is particularly important for quality control and maintaining normal physiologic parameters.

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