The Clinical Application of Acute Normovolaemic Haemodilution in Oral and Maxillofacial Surgeries

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Abstract

Aim The aim of the study is to assess the efficacy of Acute Normovolaemic Haemodilution (ANH) in reducing the perioperative homologous transfusion, to compare the results of acute normovolaemic haemodilution and homologous blood transfusion in terms of Hb%, PCV%, and to assess the cost effectiveness of ANH with homologous transfusion.

Methods 30 healthy patients between the age of 14–70 years, who required a maxillofacial surgical procedure under general anaesthesia with haemoglobin level of 12 gm% or above, PCV 30% or above and where postoperative blood transfusion was not expected to be beyond one pint, were selected. The patients were randomly divided into two groups of 15 patients each. The group I patients were subjected to ANH and the group II patients were transfused 1 pint of compatible banked, homologous blood and mean haemoglobin and PCV was compared in 1st, 3rd and 7th post-operative day in both the groups.

Result Patients who received ANH had $p < 0.05$ than patients who received homologous transfusion by using student's paired *t*-test in terms of Hb% and PCV%.

Conclusion It was concluded that ANH is more effective compared to homologous bleeding time.

Keywords Blood transfusion · Acute normovolaemic haemodilution · Supra omohyoid neck dissection · Pectoralis major myocutaneous flap

Introduction

The increasing number of surgeries has placed great demand on the blood banks for supply of blood and blood products [1].

Blood transfusion is the process of transferring blood or blood based products from one person into the circulatory system of another. Blood transfusions can be life saving in some situations, such as massive blood loss due to trauma. It is also used to replace the lost blood during surgery [2].

Blood transfusion can be grouped into two main types: Homologous transfusions or transfusion using the stored blood of others. Autologous transfusions or transfusions using one's own stored blood [2].

In India lack of education and misconceptions about blood donation amongst the lay public makes the task of arranging homologous blood very difficult and many a times stored blood has to be used in place of fresh blood during operations [1].

In recent years, it has been clearly shown that HIV, Hepatitis B, C, CMV and HTLV are transmitted by blood transfusions. In addition, organisms such as *treponema pallidum*, *microfilaria* and the protozoa responsible for malaria and *trypanosomiasis* are carried in blood [1].

Blood transfusions can introduce a multitude of foreign antigens [3].

Immune and allergic reactions, alterations in host immune function and bacterial contamination are other hazards of homologous blood transfusion [1].

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The term ‘Autologous transfusion’ describes the administration of any blood component, which has been donated by intended recipient. Autologous transfusion can be done by pre-operative donation, intraoperative salvage, acute normovolaemic haemodilution and post operative collection. Autologous blood is considered to be safest blood, which can be given to the patients [1].

ANH (Acute normovolaemic haemodilution) has become popular due to better understanding of cardiovascular physiology, tissue perfusion and tissue oxygenation with extreme haemodilution [1].

There is minimal preoperative preparation for both, the patient and staff, which makes ANH suitable for both emergency and elective procedures [4].

The functional quality of blood progressively deteriorates with duration of storage. There is gradual fall in pH, rise in free plasma haemoglobin due to RBC lysis, rise in potassium, lactic acid and ammonia levels. Functional platelets are almost absent beyond 24 h of collection and there is a fall in the levels of factor V and VII along with depletion of ATP and 2–3 DPG. Acute normovolaemic haemodilution avoids the problem that occurs with storage of blood as functional properties of blood are preserved [1].

Acute normovolaemic haemodilution is not only safe and effective method of reducing total requirement of homologous blood, but reduced blood viscosity and improved micro-circulation can be an added benefit in plastic and reconstructive surgery.

Keeping this in mind the present study was undertaken to evaluate the efficacy of ANH and comparing it with the homologous transfusion in various parameters.

Materials and methods

The present study was carried out in the department of oral and maxillofacial surgery, Acharya Vinoba Bhave Rural Hospital Sawangi, (Meghe), Wardha.

Thirty, healthy patients between the age of 14 and 70 years, who required a maxillofacial surgical procedure under general anaesthesia and who had haemoglobin level of 12 g% or above and PCV% value of 30% or above and where the blood loss and requirement of post operative blood transfusion was not expected to be beyond one pint, were selected for the present study. The intra operative blood loss and requirement of post operative blood transfusion was arbitrarily anticipated on the basis of the opinion of the senior surgeons based on their clinical experience. The patients were randomly divided in a sequential manner in two groups i.e. group I and group II of 15 patients each. The group I patients were subjected to ANH and the group II patients were transfused 1 pint of compatible banked, homologous blood.

Procedure for ANH

The procedure was carried out on the operation table after induction of general anaesthesia. All the vital parameters of the patient was recorded before starting the procedure. The BP apparatus cuff was inflated to 120 mm of Hg and under all aseptic and universal precautions an antecubital venepuncture was done using wide bore (16 gauge) iv canula to prevent hemolysis due to friction and the blood was collected in a blood collection bag containing 49 ml of CPD-A anticoagulant for collection of 350 ml blood. The blood collection bag was shaken intermittently to ensure proper mixing of anticoagulant and prevention of clotting. Simultaneously, an infusion by a separate peripheral iv line was started at other site. Replacement of the collected blood was done with 3 pints of Ringer lactate solution, taking care that normovolaemic state is maintained at all the times. The patients were closely monitored through out the blood collection procedure. The collected blood was stored at the operating room temperature of 22–24°C.

The surgical procedure was carried out and intra operative fluid and electrolyte balance management was done as per the routinely followed protocol. The intra operative blood loss was assessed arbitrarily by measuring the collection in the suction bottle and weight of the soaked gauze pieces/sponges.

The transfusion with autologous or homologous blood was started in group I and group II patients, respectively, after the accomplishment of the surgical procedure and complete haemostasis was achieved. The average time required for the surgery was 2 hours. The vital parameters were monitored during the process of transfusion. Post transfusion haemoglobin and PCV% were recorded on 1st, 3rd and 7th day in both the groups of the patients [1] (Tables 1, 2, 3, 4; Figs. 1, 2).

Discussion

A major problem during Head and Neck cancer surgery is the extensiveness of the surgical procedure and major blood loss, often requiring intraoperative and/or post operative blood transfusions. Lack of education and misconceptions about blood donation amongst the lay public makes the task of arranging homologous blood very difficult in rural India. Mostly banked blood has to be used in place of fresh blood during operations. The stored banked blood steadily loses its quality.

To overcome these drawbacks of homologous blood transfusion, autologous blood transfusion has been used as an alternative in selective circumstances.

Acute normovolaemic haemodilution minimizes transfusion transmitted diseases, minimizes red cell

Table 1 Master chart group I: patients in whom acute normovolumic haemodilution was done

S. No.	Reg. No.	Name of Patient	Age (in years)	Sex	Type of surgery	Pre op assessment		Post op assessment 1st day		3rd day		7th day		Units transfused
						Hb (gm%)	PCV (%)	Hb (gm%)	PCV (%)	Hb (gm%)	PCV (%)	Hb (gm%)	PCV (%)	
1	0632547	R.G	26	M	Bilateral le fort-III #	12	32	11	32.4	11.6	31.6	11.8	31	1pint ANH
2	0658061	A.E	18	M	Wide local excision with chemical curettage and primary closure	13.5	39.7	12.4	36.8	12.9	36.8	13	36.9	1pint ANH
3	0660345	G.F	44	M	Release of fibrous bands and reconstruction with nasolabial flap	12.2	36.5	11.8	36	11.2	33	11	31.8	1pint ANH
4	0662608	N.C	36	M	Release of fibrous bands and reconstruction with nasolabial flap	12	34	10.8	33.01	11	33.4	10.8	30.8	1pint ANH
5	0650580	H.B	45	F	Marginal mandibulectomy and reconstruction with nasolabial flap	12.6	34	11.8	32.8	11	31.4	10.9	31.2	1pint ANH
6	0655358	I.P	35	M	Hemimandibulectomy with SOND and reconstruction with forehead flap	12.2	36	11	34.6	11.2	34.8	11	34.1	1pint ANH
7	0659172	S.K	49	M	Marginal mandibulectomy and reconstruction with nasolabial flap	15.5	39.5	13.9	36.6	12.9	36	12.4	36.4	1pint ANH
8	0651290	V.P	73	M	Segmental resection with SOND and reconstruction with PMMC flap	15.7	44.4	13.4	38.8	12.8	36.6	12.6	36	1pint ANH
9	0659976	G.N	35	M	Segmental resection with SOND and reconstruction with forehead flap	13.4	36	11.8	34.6	11.2	33.6	11.6	33.8	1pint ANH
10	0617998	S.M	20	M	Wide local excision of lesion with SOND and reconstruction with forehead flap	13	32.4	11.6	32	11	31.2	11.2	31.2	1pint ANH
11	0617473	J.B	18	F	Wide local excision of lesion with SOND and reconstruction with forehead flap	13	34	11.1	32.4	11	31.6	11.2	32.2	1pint ANH
12	616448	S.L	45	M	Wide local excision of lesion with SOND and reconstruction with PMMC flap	12.4	36	10.6	32	10	31.2	10.2	31	1pint ANH
13	0658154	M.	41	M	Segmental resection with SOND and reconstruction with PMMC flap	12.6	37.4	10.4	30.9	10	30.6	10	30	1pint ANH
14	0624729	N.J	60	M	Segmental resection with SOND and reconstruction with forehead flap	13.8	38	12	34	12.2	34.8	11.2	31.2	1pint ANH
15	528641	N.M	40	M	Wide local excision of lesion with primary closure	14.8	43.6	12.6	42	12.8	42.3	13	43	1pint ANH

alloimmunization, reduces risk of febrile or allergic reactions, reduces risks of ABO compatibility, reduces risks of bacterial contamination, it lends itself to both elective and non-elective surgeries, reduces homologous blood exposure. The autologous blood is relatively fresh since it is transfused within 2–3 h. It can be used in patients with systemic infections and is more economical than homologous blood. A majority of patients are eligible for acute normovolaemic haemodilution; however, in the present

study, patients with underlying systemic disease were excluded.

In acute normovolaemic haemodilution since blood is diluted with 3 pints of Ringer lactate solution there is haemodilution hence, the blood lost intraoperatively is in a diluted form and the relative blood loss is less. There is decreased blood viscosity following administration of Lactated Ringer's solution which is also one of the important factors for the survival of flaps used in

Table 2 Master chart group II: patients who received homologous blood transfusion

S. No	Reg. No.	Name of Patient	Age (in years)	Sex	Type of surgery	Pre op assessment		Post op assessment 1st day		3rd day		7th day		Units transfused
						Hb (gm%)	PCV (%)	Hb (gm%)	PCV (%)	Hb (gm%)	PCV (%)	Hb (gm%)	PCV (%)	
1	530433	B.P	62	M	Wide local excision of lesion with SOND and reconstruction with forehead flap	12.6	32	9.6	30	10	30.1	9.8	30	1 pint homologous (patient was febrile after transfusion)
2	0612548	K	29	M	Hemimandibulectomy with SOND and reconstruction with forehead flap	12.1	34.1	9.4	30	9.6	30.2	9.8	31	1 pint homologous
3	626961	R.S	25	M	Marginal mandibulectomy and reconstruction with nasolabial flap	13.8	38.7	10.6	31.8	10.2	31	9.8	30	1 pint homologous
4	0622996	P.D	47	M	Hemimandibulectomy with SOND and reconstruction with PMMC	12.2	34	9.2	31.8	9	31	9.2	30	1 pint homologous
5	629758	S.I	40	M	Segmental resection with SOND and reconstruction with PMMC	13.2	37.5	11.2	32.6	11	32.4	10	31	1 pint homologous
6	0651023	D.C	55	M	Hemimandibulectomy with SOND and reconstruction with forehead flap	14.3	38.7	12	36	11.2	34	11	32	1 pint homologous
7	0657312	B.D	56	M	Hemimandibulectomy with SOND and reconstruction with PMMC	13.2	38	10.8	32	10	31.4	9.8	30	1 pint homologous
8	0658653	D.I	50	M	Hemimandibulectomy with SOND and reconstruction with nasolabial flap	11.9	33.2	9.8	29.4	9.9	29.8	10	30	1 pint homologous
9	0659972	P.	34	M	Hemimandibulectomy with SOND and reconstruction with PMMC	12.2	34	9.8	30	10	31	10.2	31.4	1 pint homologous (patient was febrile after transfusion)
10	0658381	G	47	M	Marginal mandibulectomy and reconstruction with nasolabial flap	13.6	40	10.4	32	10.4	32.1	10.6	32.4	1 pint homologous
11	0658189	S.G	42	M	Marginal mandibulectomy with primary closure	12.7	38.6	10.9	34	11	34.2	11.2	34.3	1 pint homologous
12	0608278	V.H	65	M	Segmental mandibulectomy with SOND and primary closure	12.9	38.1	10	32	9.9	33	10	31.2	1 pint homologous
13	658191	V.R	42	M	Segmental mandibulectomy with SOND and primary closure	12.6	36.5	9.9	32	9.8	32	9.6	30.4	1 pint homologous
14	0661861	S.B	20	M	Marginal mandibulectomy and reconstruction with nasolabial flap	16.3	40	14	38	14.2	38.2	13.9	36	1 pint homologous
15	0661348	K.D	50	F	Segmental mandibulectomy with SOND and reconstruction with forehead flap	13.8	42.4	9.6	28.8	9.9	28.8	10	30	1 pint homologous (patient was febrile)

reconstructive oral and maxillofacial surgery and also reduces the risk of thromboembolic accidents. Since the blood loss is in diluted form, the haematocrit value is depleted less significantly as compared to the normal procedures in place. In patients receiving autologous blood transfusion, postoperatively the natural killer cells and lymphokine activated cell activities were modulated. This implies that autologous blood transfusion is not

immunologically neutral, but has an intrinsic immunomodulatory potential [5].

In acute normovolaemic haemodilution fresh blood of the patient is used for replacement hence the disadvantage of stored blood like depletion of various factors is overcome. In the present study, there was no significant statistical difference in mean postoperative Hb% and PCV% in patients who received ANH. Whereas, patients

Table 3 Comparison of Hb% in both groups at various time intervals

Time period	Group	Sample (n)	Mean	SD	Std. error mean		
(a) Descriptive statistics							
Pre-operative	Group I	15	13.24	1.22	0.31		
	Group II	15	13.16	1.12	0.28		
Post-operative 1st day	Group I	15	11.74	1.00	0.25		
	Group II	15	10.45	1.26	0.32		
Post-operative-3rd day	Group I	15	11.52	.98	0.25		
	Group II	15	10.40	1.19	0.30		
Post-operative-7th day	Group I	15	11.46	0.93	0.24		
	Group II	15	10.32	1.11	0.28		
Post-op day	<i>t</i> -test for equality of means						
	<i>t</i> -value	Degrees of freedom	<i>P</i> -value	Mean difference	Std. error difference	95% Confidence interval of the difference	
						Lower	Upper
(b) Students' unpaired <i>t</i> -test							
0	0.12	28	0.90 NS, <i>P</i> > 0.05	−0.15	1.22	−2.65	2.34
1	2.55	28	0.01 S, <i>P</i> < 0.05	2.56	1.00	0.51	4.62
3	2.06	28	0.04 S, <i>P</i> < 0.05	2.04	0.98	0.01	4.07
7	2.09	28	0.04 S, <i>P</i> < 0.05	2.10	1.00	0.04	4.15

Table 4 Comparison of mean PCV% in both groups at various time intervals

Time period	Group	Sample (n)	Mean	SD	Std. error mean		
(a) Descriptive statistics							
0	Group I	15	36.90	3.67	0.94		
	Group II	15	37.05	2.97	0.76		
1	Group I	15	34.59	3.00	0.77		
	Group II	15	32.02	2.47	0.63		
3	Group I	15	33.99	3.07	0.79		
	Group II	15	31.94	2.29	0.59		
7	Group I	15	33.41	3.45	0.89		
	Group II	15	31.31	1.77	0.45		
Time period	<i>t</i> -test for equality of means						
	<i>t</i> -value	Degrees of freedom	<i>P</i> -value	Mean difference	Std. error difference	95% Confidence interval of the difference	
						Lower	Upper
(b) Students' unpaired <i>t</i> -test							
0	0.12	28	0.90 NS, <i>P</i> > 0.05	−0.15	1.22	−2.65	2.34
1	2.55	28	0.01 S, <i>P</i> < 0.05	2.56	1.00	0.51	4.62
3	2.06	28	0.04 S, <i>P</i> < 0.05	2.04	0.98	0.01	4.07
7	2.09	28	0.04 S, <i>P</i> < 0.05	2.10	1.00	0.04	4.15

who received homologous blood transfusion, showed statistically significant decrease in mean Hb% and PCV% as compared to preoperative values. Moreover 3

patients who received homologous transfusion had febrile episode but none of the patients had any allergic reactions.

Fig. 1 Comparison of mean Hb% in both groups at various time intervals

Fig. 2 Comparison of mean PCV% in both groups at various time intervals

Conclusion

Acute normovolaemic haemodilution is most likely to be safe, efficacious and cost effective which is very helpful in a rural setup like ours, where many patients are from low socioeconomic strata and are not in a position to afford the cost of banked blood [6].

In view of the several advantages offered by ANH like being more physiological, safe, and helpful in minimizing the blood loss intraoperatively, it does not require any special technical expertise and is also economical. It is an effective tool in the surgeon's hand and can be of great help in improvising the replacement protocols.

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