PERIOPERATIVE NORMOVOLAEMIC HAEMODILUTION IN MAJOR ELECTIVE ORTHOPAEDIC SURGERY IN LUSAKA.

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A Dissertation submitted in Partial Fulfilment of the Requirements for the award of the

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COPY DECLARATION

This Dissertation represents my work, and that it has not previously been submitted for a degree at the University of Zambia or any other University.

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APPROVAL

This dissertation of Dr Lishman Lee Kosipre is approved as fulfilling part of the requirements for the award of the Degree of Master of Medicine in Orthopaedics by the University of Zambia.

Subject to Examiner's Report.

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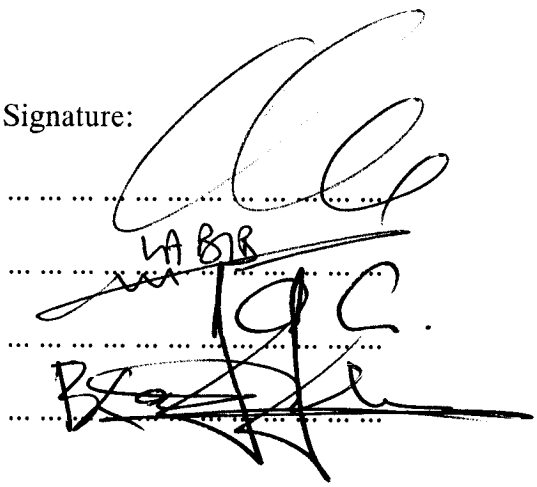

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DEDICATION

To the memory of my dear mother who passed away to the great beyond during the period of my training.

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ABSTRACT

Perioperative Normovolaemic Haemodilution was done on twenty three patients who had major elective orthopaedic surgery both at the University Teaching Hospital, Lusaka and the Zambian – Italian Orthopaedic Hospital, Lusaka between July, 1997 and June, 1999.

There were twelve males and eleven females with ages ranging from 13 to 78 years (mean 42.1 years). The preoperative haemoglobin of these patients ranged from 9.2g/dl to 16.8g/dl (mean 12.9g/dl). The postoperative haemoglobin measured at 72 hours ranged from 7.0g/dl to 13.1g/dl (mean 10.6g/dl); while the postoperative haemoglobin for those patients that stayed up to two weeks ranged from 7.4g/dl to 14.0g/dl (mean 10.6g/dl). The drop in haemoglobin at 72 hours postoperatively ranged from 0.3g/dl to 5.8g/dl (mean 3.7g/dl).

Hip surgery was the commonest operation performed. There was one mortality (4.4%); all the other patients had uneventful recovery. None of the patients had homologous blood transfusion and no operation was cancelled due to failure of technique.

DEFINITION

Normovolaemic haemodilution is the removal of blood from a patient and replacement with crystalloid or colloid solution immediately before or after induction of anaesthesia. The procedure is completed prior to the start of surgical blood loss. The blood is then available for re-infusion as necessary when considerable loss of the diluted blood has occurred.

HISTORY OF BLOOD TRANSFUSION

Although the story of blood transfusion is over 300 years old, as a viable therapeutic procedure it took its place in medicine just before the Second World War. Problems of immunological incompatibility, coagulation and storage had to be solved first[1].

After transfusion experiments in animals, the first recorded transfusion in man was on June 15, 1667 in Paris by Jean Baptiste Denis (1620-1704)[1]. He transfused a 17 year old boy suffering from fever and collapse with repeated phlebotomies using 270ml of blood from the carotid artery of a sheep. This first animal to man transfusion did not result in any untoward reaction. On November 20, 1667, Lower performed a calf to man transfusion without any reaction[1]. However, Denis' fourth animal to man transfusion ended in a disaster due to a severe incompatible blood reaction causing circulatory collapse. The patient was insane and it was thought that the blood of a meek and gentle calf might calm him. Denis was charged with murder but later acquitted. Following this, Parliament on April 17, 1668 in Paris banned further transfusion experiments.

In 1818, the issue of blood transfusion was resurrected by James Blundell (1790 - 1878) of Guy's and St. Thomas' Hospitals, London, England. He was concerned about death from post partum haemorrhage. After a series of animal experiments, he concluded that man to man transfusion was possible and on September 26th, 1818, a moribund patient with carcinoma of the stomach was given by means of a syringe 350-400ml of blood from several donors over a period of 30 minutes[1]. The patient improved but died two days later. Blundell subsequently transfused six patients with severe post partum haemorrhage but they all died because the blood was administered

late. His first success was in 1829 and other obstetricians soon followed his example but problems of clotting and reaction prevented general acceptance of blood transfusion, which was often used only when all hope had faded.

In 1900, Samuel Shattock in England observed that human red cells could be agglutinated by serum of another human[1]. Karl Lansteinner (Nobel prize winner)[1] discovered three blood groups amongst his laboratory staff in the University of Vienna, the fourth was discovered by De Castello and Starli in 1902. Lansteinner also participated in the discovery of the Rhesus (Rh) antigen. With these agglutinins known, the occurrence of transfusion reactions could now be scientifically explained.

Arthus and Pages in 1890 at the University of Fribourg demonstrated the anticoagulant effect of sodium citrate and oxalate; but citrated blood was only introduced in 1914 by M. Hustin (1882 -1967) of Belgium. Two years later, Rous and Turner prolonged the life span of red cells by the addition of glucose, thus enabling storage of blood. Bernard Fantus (1874-1940) in 1937 organised a blood bank in Cook Country Hospital, Chicago. Citrated blood was first used on a large scale in the Spanish Civil War. During the Second World War, collection, storage and usage of blood on a large scale became established[1].

In 1927 V.N. Shanov[1] in Russia observed that cadaver blood was not toxic; with the result that Sergei S. Yudin (1891-1954) in Moscow successfully transfused 420ml of cadaver blood to resuscitate a patient in 1930. By 1937, Yudin had done over 1,000 cadaver blood transfusions with very few reactions. Cadaver blood especially of people dying suddenly did not clot because of fibrinolysis and so required no

anticoagulant. With the increasing use of other cadaver organs for transplantation, cadaver blood transfusion might also, with adequate precaution, become universally acceptable.

BLOOD GROUPING AND CROSS-MATCHING

The term "blood groups" is applied to the genetically determined antigens that can be detected on the red-cell surface by specific antibodies. The ABO system is by far the most important in clinical medicine because the associated antibodies occur naturally. The Rhesus (Rh) system is the next most important.

There are four major ABO blood groups - Group A, B, AB and O. The A group is further subdivided into A_1 and A_2 with majority of the A group belonging to the A_1 subgroup. The difference between A_1 and A_2 red cells is related to the number of A antigenic sites on the cell membrane.

Cells containing D antigens are termed Rh-positive and those which lack it are Rh-negative. It is the D antigen that is of crucial importance in causing haemolytic disease of the newborn and transfusion reactions. Following the introduction of Rh-positive cells into Rh-negative persons, they develop anti-Rh and they are in danger of a transfusion reaction when they are re-exposed to Rh-positive cells[8].

The ABO grouping of a blood sample is performed on a tile or in tubes, preferably at room temperature. Two drops of a 2% red-cell suspension in normal saline are mixed with one drop of potent anti-A and Anti-B serum respectively, and the development of agglutination is noted. If this occurs with anti-A, the cells are group A, and with anti-B, group B. If both sera agglutinate the red cells they are group AB, and if there is no agglutination with either, they are Group O. Agglutination is easily recognised with the naked eye but its absence should be confirmed microscopically. Routinely, the patient's serum is tested with group A, B and O cells to confirm the presence of the

expected alloagglutinins, anti-A and anti-B. This is termed "reverse grouping". Rhesus grouping is carried out by adding a drop of 5% red cell suspension in saline to a drop of complete anti-D serum in a serological tube, and the mixture is incubated at 37^0C for an hour, after which the tube is centrifuged and examined for agglutination. The presence of agglutination indicates that the cells are Rh-positive.

Once the ABO and Rh blood groups of donor and recipient are known, a cross-match is done before transfusion can be performed. The donor's red cells are tested against the recipient's serum.

The donor's serum is less important, because any antibodies it may contain should be so diluted by the recipient's plasma as to become insignificant. Cross-matching is always necessary because a) there may be an error in sample identification, and b) the recipient's serum may contain antibodies other than anti-A, anti-B, and anti-D. Approximately 1% of hospital patients possess antibodies outside the ABO and Rh systems[8].

INTRODUCTION

Normovolaemic haemodilution is synonymous with euvolaemic or isovolaemic haemodilution. It has been used to describe the deliberate production of a low haemoglobin level immediately before an operation, by taking blood from the patient while maintaining normovolaemia, with the objects of:

1. Improving the micro-circulatory flow due to a reduction in the viscosity of the blood, and
2. Obtaining autologous blood which eliminates or reduces the need for allogeneic blood transfusion[2].

It is a form of autologous transfusion and since the blood donation is carried out in the operating suite, it is widely referred to as perioperative or intraoperative haemodilution. Haemodilution involves isovolaemic exchange of whole blood with a crystalloid or colloid solution in order to gain autologous blood while maintaining normovolaemia.

In prior deposition of autologous blood for transfusion, patients donate blood at weekly intervals which is stored in the blood bank before the date of the surgery. The blood is kept liquid if surgery is scheduled within five weeks or else it is frozen[4]. The liquid units are stored at 1-6°C with citrate phosphate dextrose adenine solution-1 as the anticoagulant; they become outdated thirty-five days after donation[4,12,19]. The frozen units are stored at a temperature of about –65°C, with glycerol added as a cryoprotective agent.

Before re-infusion, the frozen red blood cells are thawed and the glycerol is removed by washing. This process takes thirty minutes and results in the loss of 10% of the red blood cells. Frozen units must be transfused within twenty-four hours after thawing because of the risk of bacterial contamination[4].

Homologous blood transfusion has been the practice to compensate for blood loss in major surgery for many years now. It is not ideal because of its inherent risks.

Transfusion of homologous blood is dangerous because of:

1. Incompatibility (usually the result of laboratory or documentation errors).
2. Transmission of diseases - malaria, hepatitis, cytomegalovirus, Human Immunodeficiency Virus (HIV) - window period of undetected antibodies and other diseases.
3. Severe overload of the immune system e.g. colonic cancer spreads more readily if colectomy patients have been transfused[22].

In addition to all these, homologous transfusion is more expensive because of cost of finding donors, grouping and cross-matching, screening and storage, all of which are not necessary in haemodilution.

Autologous transfusion is particularly useful for patients with rare blood groups and for those with red cells antibodies. In Zambia, less than 3% of the population is Rhesus negative, so Rhesus negative blood is very difficult to provide in an emergency[14].

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Poorly defined fear of a positive test for HIV (Human Immunodeficiency Virus) as a voluntary blood donor and an increased prevalence of risk behaviour in the general population have reduced the number of people willing to donate blood. Trauma and development in surgical techniques have increased the demand for blood transfusions. The result is that many scheduled operations are postponed or cancelled due to the lack of available blood[3].

Diseases and deaths related to the transfusion of homologous blood have received national attention, and many physicians have noted concern among patients that has caused an increased hesitancy to undergo elective surgery and to receive donated blood. It is important for orthopaedic surgeons to have a basic understanding of blood products and of the complications that are associated with their use, as well as a knowledge of the alternatives that can be used to avoid these complications[4].

The concept of autologous transfusion was first proposed by Blundell, in 1818, as a potential life-saving technique for patients who had a massive haemorrhage[7]. However, the use of autotransfusion in orthopaedic surgery was first reported by James Duncan of Edinburgh in 1886, in a patient who underwent autotransfusion during amputation of a leg. The blood was caught in a vessel containing a solution of phosphate of soda that was used as an anticoagulant and then the blood was returned into the femoral vein through the incision. Two months later, he applied the same technique in an amputation through the hip[4].

Reports from the literature have stated that autotransfusion, is a safe, simple and effective technique[3,7,17]. The patients become involved with their own treatment programme and often are more motivated. Also, they are likely to continue to donate blood in the future, for others or for themselves[4].

Major orthopaedic operations particularly those involving the decortication of large areas of bone frequently necessitate the replacement of a substantial amount of lost blood. The advantage of using autologous blood eliminates well known potential risks of homologous blood transfusion; exposure to carrier transmitted diseases such as hepatitis, acquired immunodeficiency syndrome, technical errors in typing and cross-matching, allergic reactions sensitization and iso-immunisation[5]. Other advantages include conservation of blood products, acceptance by some members of religious groups that consider homologous blood to be unacceptable and also potential financial savings[6].

A pre-deposited autologous blood transfusion programme has some disadvantages compared to intraoperative haemodilution and autotransfusion such as organisation and blood banking problems, loss of platelet activity, and other clotting factors, increased oxygen affinity and increased potassium concentration and decreased pH. It also needs careful planning: the date of the operation needs to be fixed, which can be a problem in the public hospital system[5]. If the operation is cancelled, blood is wasted. Studies revealed that approximately 50% of pre-donated autologous blood units are routinely wasted and rates as high as 70% has been reported[13].

Although intraoperative haemodilution does not make very large amounts of autologous blood available, it is much more convenient for the patient than prior deposit autologous blood donation and the blood itself is fresh, with viable platelets, if kept at room temperature[2]. It may indeed be an attractive alternative for many surgical operations.

OBJECTIVES

The main objective of this study was to determine if autologous transfusion by intraoperative haemodilution is a safe, and reliable technique that can be used as an effective alternative to homologous blood transfusion in elective major orthopaedic operations.

It was also to look into how practicable this technique can be applied in our practice and its usefulness in reducing homologous blood transfusion and the work load of the Blood Bank staff in an area where shortage of personnel exists.

RATIONALE

The rationale of this study is to document the technique of haemodilution as practised in the Orthopaedic Unit, and thereby maintain it as a policy for use in patients undergoing major elective orthopaedic operations.

LITERATURE REVIEW

In the last twenty years, there has been a growing awareness within the medical community and the general public of the risks of transmitting disease through transfusion of blood. While risks associated with transfusions have always been present, the spectre of AIDS (Acquired Immune Deficiency Syndrome) has greatly heightened this awareness. Some patients have refused regular blood transfusions, demanding "safer" blood. Thus began the search for alternatives to traditional blood banking[6].

It has been estimated that the incidence of post-transfusion hepatitis is 1% per unit of blood that is transfused, and that most cases of post-transfusion hepatitis are caused by the non-A, non-B hepatitis virus[11]. Despite the best laboratory screening tests available, infection with human immunodeficiency virus still occurs as the result of homologous transfusions and has been reported to occur in ten to twenty-six per one million transfusions[10]. These considerations have resulted in strong recommendations that orthopaedic surgeons consider the use of autologous blood in any patients who are expected to require blood components after an elective operation.

The question of liability of the physician in transfusion related acquired immunodeficiency syndrome recently has been suggested in court, and settlements against physicians and hospitals could be the result[11]. Autologous transfusion should be regarded as the standard of care[19], in order to avoid this. Allogeneic blood transfusion is a tissue transplant and the resulting suppression of the immune system leaves the patient open to postoperative infection[19].

A study [19] found the postoperative infection rate among 109 orthopaedic patients who received allogeneic transfusions was 20.8%. This compared with only 3.3% out of 60 patients who received autologous blood. Those receiving allogeneic blood had an average hospital stay of 12.3 days, while those receiving autologous blood stayed an average of 9.7 days. In addition to extra days of bed occupancy, the cost for those receiving allogeneic blood was also increased by charges for extra antibiotics and laboratory tests[19]. Nevertheless, blood should always be used with circumspection; it should not be used, for example, for "top-up", for hastening discharge, or when a course of iron therapy can be safely prescribed[12].

Apart from better surgical techniques to reduce blood loss, techniques available for conserving blood during major operations include pre-deposited autologous blood transfusion, intraoperative or postoperative blood salvage, induced hypotensive anaesthesia and intraoperative haemodilution and autotransfusion[5]. The use of regional anaesthesia has shown measurable reduction in blood loss which may be useful in selected patients and operations.

It was for long considered that a preoperative haemoglobin concentration of 10g/dl was the lowest value acceptable for safe elective surgery. If the three determinants of oxygen availability - cardiac output, arterial oxygen saturation and haemoglobin concentration are all reduced by one third, oxygen availability will be only 300 ml/min (Nunn and Freeman, 1964a). Nunn and Freeman (1964a) pointed out that a great deal of surgery throughout the world is performed on patients with haemoglobin concentrations of less than 8g/dl and most of them not only survive but tolerate this level of anaemia well.[2] The need for transfusion must be individualised for each

patient[5,9,10]. Data have supported the theory that changes in cardiac output and mixed venous concentrations are the best indicators for the need for transfusion[10].

Enthusiasm for perioperative normovolaemic haemodilution has been generated by the successful colloid and crystalloid resuscitation of patients in hypovolaemic shock and by patients who refused blood transfusion but who nevertheless experienced satisfactory outcomes with colloid or crystalloid solutions[20].

Degree of haemodilution varies according to the patient's preoperative condition, total body surface area, and duration of surgery[20].

A Consensus Development Conference on perioperative red blood cell transfusion came up with the following conclusions[9]:

1. There are identifiable risks to red blood cell transfusion, including transmission of infection and immunosuppression. The risk of infection and even death from homologous transfusion can not be eliminated completely with current screening methods.
2. There is little evidence to suggest that a haemoglobin value below ten grams per decilitre (10g/dl) or a haematocrit below thirty percent (30%) alone should serve as an indication for transfusion. Rather no single measure can replace good clinical judgement as the basis for decisions regarding perioperative transfusion. Experience suggests that otherwise healthy patients who have a

haemoglobin value of ten grams per decilitre or more rarely need perioperative transfusion.

3. While adequate oxygen tension and tissue perfusion are critically important for wound healing, there is no evidence to support the opinion that a certain level of haemoglobin or haematocrit is needed to promote wound healing. Moreover, there is no clear evidence that moderate anaemia increases the frequency or severity of postoperative infections.

   Thus, the report concluded that perioperative transfusion should be administered on an individual basis and not on the basis of a specific level of haemoglobin or haematocrit.

4. The report also addressed the alternatives to homologous transfusion[9]. These alternatives include pre-deposit autologous blood transfusion programmes, intraoperative blood-salvage programmes, selection of patients for intraoperative isovolaemic haemodilution, pharmacological approaches to blood loss and directed donations.

Messmer (1975)[2] described the way in which haemodilution could be used in patients immediately before surgery: up to a maximum of 1,800 - 2,000ml of blood is withdrawn with simultaneous infusion of a colloid solution, producing a fall in the packed cell volume (PVC) to about 0.25. Cardiac output increases, but heart rate, central venous pressure (CVP) and mean arterial pressure remain essentially unchanged. When the intraoperative blood loss exceeds 300ml, retransfusion of

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autologous blood is started. It is claimed that this method is adequate for dealing with intraoperative blood losses up to 2000ml, and that additional blood (i.e. allogeneic) is seldom needed. Messmer et al (1972) emphasised that:

1. an increase in cardiac output must be regarded as an indispensable compensatory mechanism,
2. the tolerance and safe limits of clinical haemodilution are dependent on the contractile state of the myocardium, and
3. the following are to be regarded as contraindications: myocardial failure, coronary artery disease, obstructive lung disease and pre-existing anaemia[2].

Compensatory mechanisms that result from haemodilution include increased overall blood flow rates, increased oxygen extraction, and reduced affinity of oxygen to haemoglobin that shifts the dissociation curve to the right. As long as the patient remains well oxygenated, increase in cardiac output compensates for the decrease in haemoglobin concentration[20].

Neither special equipment nor personnel are required for perioperative haemodilution or retransfusion and there are no delays for repeated phlebotomy[20].

Other benefits of perioperative haemodilution includes postoperative improvements in pulmonary, renal and myocardial function[20].

Acute normovolaemic haemodilution and haemapheresis for blood component sequestration has also been reported for use in patients having spinal surgery[21]. Up to 30% of the estimated total blood volume can be collected safely and sequestered by haemapheresis from a patient with a normal red cell mass, using acute normovolaemic haemodilution. The blood components are separated into autologous red cells, plasma and platelets which are retransfused to the patient postoperatively.

MATERIALS AND METHODS

All patients who satisfied our selection criteria and were to undergo elective major orthopaedic surgery between July 1997 and June 1999, at the University Teaching Hospital, Lusaka and the Zambian – Italian Orthopaedic Hospital, Lusaka were included in the study for normovolaemic haemodilution. Criteria for selection were as follows:

1. Haemoglobin (Hb) > 8g/dl.
2. Adults: Predicted operative blood loss > 15 ml/kg.

   Children: Predicted operative blood loss > 10 ml/kg.
3. Contraindications:
   - Sickle cell disease.
   - Compromised heart or lung disease.
   - Compromised liver or renal disease.
   - Bacteraemia.
   - Pre-existing anaemia.
   - Bleeding disorders.

Autodonation was carried out in the theatre suite by collecting one, two or three units of blood (depending on the type of operation and preoperative haemoglobin level) via the blood bag needle inserted into a cubital vein while the blood flowed into a standard blood bag containing an anticoagulant. Normal saline or Ringer's lactate was simultaneously infused through a second intravenous line. The volume infused was to be two to three times the volume of blood collected or equal volume in the case of colloid solution[3,14]. The patient's blood was clearly labelled after collection

and stored at room temperature in the theatre.

The allowable blood loss (ABL) from the patient was calculated using the following formula:-

$$ABL = \frac{EBV. (initial\ Hb - lowest\ desired\ Hb).}{Mean\ of\ initial\ and\ lowest\ desired\ Hb.}$$

ABL = Allowable Blood loss.

EBV = Estimated blood volume - commonly accepted to be 70 ml/kg or more accurately 70 ml/kg (male), 65ml/kg (female). If the patient is lean, less 5 ml/kg, muscular add 10 ml/kg and obese individuals less 10 ml/kg.

Normogrames for easy reading of the Estimated Blood Loss (EBL) or Allowable Blood Loss (ABL) using the starting Haematocrit (HCT) of the patients have been developed. These are shown both for male and female patients in the appendix (reproduced with permission of Dr. Carl H. Nielsen). An estimation of the amount of blood loss during surgery was done by measuring the volume in suction bottles and estimating the blood loss on surgical drapes, gauze and abdominal packs. Also the amount of blood in the vacuum drain inserted into the wound towards the end of the operation was measured in the ward. Accurate monitoring of the patient's heart rate, blood pressure, respiratory rate, volume of crystalloid infused was mandatory and recorded.

The operation was performed just after the autodonation while the patient's blood is haemodiluted. Reinfusion of autologous blood was started when haemostasis had been obtained, at the completion of surgery, or when the estimated blood loss

equalled the allowable blood loss. The haemoglobin level was checked at 48-72 hours following the surgery and at about two weeks postoperatively. Patients were routinely placed on ferrous sulphate and folic acid tablets postoperatively. Each patient's blood sample was sent to the blood bank preoperatively for saving of serum in case there will be a need for homologous transfusion. Ethical Committee approval was obtained and all patients gave informed consent to take part in the study.

RESULTS

Twenty-three patients who had elective major orthopaedic surgery underwent perioperative normovolaemic haemodilution and autotransfusion. Eleven patients were operated at The University Teaching Hospital, Lusaka and twelve at The Zambian-Italian Orthopaedic Hospital, Lusaka. There were twelve males and eleven females with their ages ranging from 13 to 78 years (mean 42.1 years).

The preoperative haemoglobin of these patients ranged from 9.2g/dl to 16.8g/dl (mean 12.9g/dl). The postoperative haemoglobin measured at 72 hours ranged from 7.0g/dl to 13.1g/dl (mean 10.6g/dl). For those patients whose condition necessitated staying in the hospital ward for up to two weeks and beyond, the range of haemoglobin at two weeks postoperatively was 7.4g/dl to 14.0g/dl (mean 10.6g/dl). These figures are shown in the Table with the amount of blood withdrawn from each patient. The drop in haemoglobin level of the patients 72 hours postoperatively ranged from 0.3g/dl to 5.8g/dl (mean 3.7g/dl).

Fifteen patients had one unit of blood withdrawn, seven patients had two units while one had three units taken before the surgery.

The table also shows the different types of operation performed on these patients based on their preoperative diagnosis. Hip surgery was the commonest operation performed followed by spinal surgery. The amount of blood loss intraoperatively and from the suction drains in the wards ranged from 300 to 1000 ml.

None of the patients received homologous blood transfusion intraoperatively or postoperatively. One of the patients died ten hours postoperatively in the Intensive Care Unit. It was an unfortunate and unexpected death despite all precautionary measures being taken. All the other patients had uneventful recovery. No operation was cancelled because of failure of technique.

TABLE 1

NO	SEX	AGE	DIAGNOSIS	OPERATION	UNITS OF BLOOD WITHDRAWN	PREOPERATIVE HAEMOGLOBIN g/dl	POSTOPERATIVE HAEMOGLOBIN (72 HOURS) g/dl	DROP IN POST-OPERATIVE HAEMOGLOBIN 72 HOURS (g/dl)	POST-OPERATIVE HAEMOGLOBIN 14 DAYS (g/dl)
1.	M	78	Osteoarthritis of Hip.	Total Hip Arthroplasty	1	16.8	13.1	3.7	14.0
2.	M	50	Fracture Neck of Femur	Hemiarthroplasty	1	15.0	9.4	5.6	10.4
3.	F	61	Osteoarthritis of Hip	Total Hip Arthroplasty	1	14.8	11.3	3.5	-
4.	M	13	Scoliosis	Posterior Spinal fusion	1	14.7	10.2	4.5	12.4
5.	F	52	Osteoarthritis of Hip	Total Hip Arthroplasty	1	14.4	8.6	5.8	-
6.	M	52	Osteoarthritis of Hip	Total Hip Arthroplasty	2	13.9	8.3	5.6	-
7.	M	43	Fracture Neck of Femur	Hemiarthroplasty	1	13.6	8.1	5.5	8.5
8.	M	68	Osteoarthritis of Hip	Total Hip Arthroplasty	2	13.5	11.0	2.5	-
9.	F	37	Osteoarthritis of Hip	Intertrochanteric Osteotomy	1	13.4	11.0	2.4	12.0
10.	F	63	Osteoarthritis of Hip	Total Hip Arthroplasty	2	13.3	8.7	4.6	-
11.	M	71	Osteoarthritis of Hip	Total Hip Arthroplasty	2	13.3	8.5	4.8	-
12	F	16	Scoliosis	Posterior Spinal fusion	1	12.7	10.3	2.4	-

TABLE 1 CONTINUED

13.	M	53	Non-union Fracture of Femur	K-Nailing/Bone graft	1	12.4	8.1	4.3	10.7
14.	F	35	Osteoarthritis of Hip	Total Hip Arthroplasty	1	12.4	7.0	5.4	-
15.	F	24	Giant Cell Tumour of Tibia	Excision/Knee Reconstruction	1	12.1	8.9	3.2	10.2
16.	F	24	Hip dislocation (old)	Excision Arthroplasty	1	11.9	10.0	1.9	10.8
17.	F	57	Osteoarthritis of Hip	Total Hip Arthroplasty	2	11.9	9.0	2.9	10.0
18.	F	35	Spinal stenosis	Multiple laminectomy	1	11.8	11.5	0.3	-
19.	M	39	Tuberculous Arthritis of Hip	Arthrodesis of Hip.	2	11.7	8.4	3.3	9.0
20.	M	17	Osteosacorma of Humerus/Glenoid	Forequarter Amputation	3	11.4	11.6	-	-
21.	F	29	Spinal tuberculosis/ paraplegia	Spinal Decompression	1	11.4	7.0	4.4	7.4
22.	M	17	Congenital Kyphoscoliosis	Spinal Decompression	2	11.2	Died	-	-
23.	M	34	Fracture/Dislocation of spine	Hartshill Rectangle (ORIF)	1	9.2	7.5	1.7	11.6

DISCUSSION

Blood is a valuable and safe therapeutic agent, if used properly [12,14]. The ultimate goal of blood management by the orthopaedic surgeon is to eliminate the need for allogeneic blood transfusion. Although the implementation of blood screening measures has vastly reduced the risk of transmission of the human immunodeficiency virus through transfusion of donated blood products, several factors preclude the blood supply from achieving a zero-risk status[13].

Patients who receive perioperative allogeneic blood transfusions, for instance, have been reported to have higher rates of infection, perioperative blood loss, longer hospital stays, more consecutive days of fever, need more frequent administration of antibiotics, and a postoperative decrease in natural killer cells has been observed[13]. Furthermore, in a retrospective quantitative analysis of transfusion associated immunomodulation, transfusion was the most important prognostic factor for postoperative infection[13].

In this study, the lowest preoperative haemoglobin was 9.2g/dl and postoperatively (72 hours) the haemoglobin level dropped to 7.5g/dl. Fourteen days later, the haemoglobin level had risen to 11.6g/dl. This patient had a fracture/dislocation of T12/L1 vertebrae with neurological deficit and came to us some days after the incident as a referral. The fact that he was able to survive the surgery and even had a haemoglobin level of 11.6g/dl fourteen days postoperatively is noteworthy. A haemoglobin level of less than 10g/dl and a haematocrit of less than 30% alone are not sufficient indications for a transfusion and such levels are not necessary for adequate postoperative healing[9,10].

The patients all had oral ferrous sulphate and folic acid postoperatively[5]. These haematinics were prescribed to ensure maximum bone marrow haematopoeisis. Marrow activity increases three fold to four fold, achieving an increase in haemoglobin concentration of 1g/dl (replacing 1 unit) every three to five days following acute blood loss[4,15,16].

The stimulus for erythropoietic activity is the production of erythropoietin in response to anaemia or hypoxaemia. The use of recombinant human erythropoietin (Epoetin alpha), a secretory glycoprotein of 165 amino acids that is identical in sequence to endogenous human urinary erythropoietin to accelerate erythropoeisis has been reported[13]. Its physiological implications include improved tissue oxygenation and reduced need for allogeneic blood transfusion, due to increased haemoglobin concentration. Each gram per decilitre increase of haemoglobin concentration results in an increase in oxygen – carrying capacity of approximately 1.39 millilitres of oxygen per decilitre and a decrease in the need for allogeneic blood transfusion of approximately 15%[13]. Epoetin alpha is well tolerated by orthopaedic patients.

Because Epoetin alpha – accelerated erythropoiesis increases red blood-cell mass and blood viscosity, clinicians have been particularly concerned about the potential for deep venous thrombosis. However, clinical studies have not shown an increase in prevalence of deep venous thrombosis in patients managed on Epoetin alpha[13].

Epoetin alpha was not available during this study and so we had to be content with the use of oral ferrous sulphate and folic acid.

The lowest postoperative haemoglobin was 7.0g/dl from a preoperative haemoglobin of 11.4g/dl and after fourteen days the level rose to 7.4g/dl. This patient was Human Immunodeficiency Virus (HIV) seropositive. The other patient with a similar postoperative haemoglobin of 7.0g/dl from a preoperative haemoglobin of 12.4g/dl had a total hip arthroplasty. The plan was to withdraw two units of blood from her but due to difficulties encountered with venepuncture, only one unit was successfully collected. However, for a total hip arthroplasty, it is always safer to withdraw two units of blood if possible to prevent such a drastic drop and low level of haemoglobin postoperatively. Despite these low postoperative haemoglobin values, the patients healed, there was no wound break down. None of the patients received homologous blood transfusion. This shows that most patients can indeed tolerate such low levels of haemoglobin provided there is no continuing bleeding and have an uneventful recovery from major elective surgery[5].

The youngest patient in the series was 13 years of age while the oldest was 78 years. The age range in a series of 103 patients reported by Yong Liaw et al[5] was 12-87 years with a mean of 66 years. Thus the wide age range allowed for any patient who could understand the procedure or technique and be able to donate blood to have haemodilution prior to elective major orthopaedic surgery.

There were initial problems in the collection of blood especially while trying to get the second unit of blood. This was as a result of poor flow from vasoconstriction of the vessels possibly from anxiety. Blood donation is frightening to most people and with the added anxiety of the impending surgery. Subsequently, all other patients had premedication of pethidine injection of 50mg for adults and 25mg for children

intramuscularly an hour before the phlebotomy in the theatre. With this, we were able to overcome this problem of poor flow and could reasonably collect even up to three units of blood from one of the patients.

One could see from the wide range of operations performed using this technique of perioperative haemodilution that it is an attractive alternative to homologous blood transfusion. The technique can be practised anywhere, even where blood transfusion services are not available[3,14]. The only requirements are blood bags, crystalloids or colloids, and a facility for estimating haemoglobin or haematocrit.

The estimated blood loss varied from 300-1000ml in this study. This is an estimate between the surgeon and the anaesthetist as it is difficult to accurately determine the amount of blood loss in our set up. It was not possible to weigh the swabs or packs before and after surgery which should have been the ideal. Weighing could not have been used to estimate blood loss because large volumes of saline were used in irrigating the wounds. Moreover, even the amount of blood soaked on to the surgical drapes too could only be guessed as there is no system such as colourimetry technique devised to soak these materials in water and determine the exact volume of blood. Indeed, the only accurate measure was that from the suction bottle and the suction drain inserted at the operation site. There was one death in this series (4.4%). This patient presented with a diagnosis of congenital kyphoscoliosis due to hemivertebrae with worsening paraparesis. The patient had two units of blood withdrawn and replaced with two litres of crystalloid before an anterior spinal decompression using a left thoracotomy approach. The surgery went on smoothly lasting approximately four

hours and postoperatively the patient was sent to the Intensive Care Unit for observation. He recovered fully from the anaesthesia and vital signs were stable with a BP of 90/50mmHg which persistently remained so till eight hours after surgery when patient was said to have suddenly changed condition. Resuscitative measures put up in the intensive care unit could not save the life and the patient was finally certified dead two hours later (about ten hours postoperatively). The patient had four litres of crystalloids and his two units of autologous blood transfusion. He had bilateral chest tubes inserted as the right pleural cavity was inadvertently opened, the under-water seal drains were functioning well. His total urinary output was about 1800ml from time of surgery to death. An autopsy was requested and performed. The results of the autopsy, however, showed no haemorrhage, and no blood collection in the chest cavity. The Pathologist certified the cause of death to be cerebral and pulmonary oedema. This was doubtful since postoperatively the patient was not on any intravenous fluid ordered, neither was pethidine given for analgesia. In haemodilution, the amount of crystalloid used to replace the volume of blood withdrawn is usually 2-3 times the blood collected. We have only been using twice the volume of blood collected as a precautionary measure to avoid overdilution.

Effective haemodilution requires a dedicated anaesthesia team, surgeon, careful monitoring, and an efficient protocol to prevent delays and surgical morbidity[18]. In order to avoid delays and save theatre time, it is important that the haemodilution is done while a previous case is in progress so that the completion of the phlebotomy coincides with readiness of the theatre for the patient. Time wasted for perioperative haemodilution is worthwhile, however, when the inherent risks and complications of homologous blood transfusion are considered.

The commonest operation performed was hip surgery followed by spinal surgery which is in conformity with other studies[5]. Our comparatively low figure for total hip arthroplasty or hemiarthroplasty is due to the younger population structure in Zambia and the difficulties of procuring prostheses and the ability of patients to pay for them. For the reasons already stated, very little blood is available for transfusion from the Zambia Blood Transfusion Service; operations are often delayed or cancelled because of this and, in emergency situations, patients often die from exsanguination following major trauma. We feel that the use of acute perioperative haemodilution for planned major orthopaedic surgery overcomes most of these problems and enables the little homologous blood available to be kept for emergency use and patients with leukaemia and other blood disorders as well as those receiving intensive chemotherapy for cancer or following a transplant.

CONCLUSION

1. Perioperative Normovolaemic Haemodilution is a relatively safe, simple and inexpensive technique.
2. It can be practised in any hospital where operations are performed.
3. Full dedication of the surgeon and anaesthetist is required.

RECOMMENDATION

1. Perioperative Normovolaemic Haemodilution is an attractive alternative to homologous blood transfusion.
2. It should be encouraged not only in Orthopaedics but also in other Surgical specialities.

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APPENDIX

Estimated Blood Loss (EBL)

300 43
400 42
500 41
600 40
700 40
800 39
800 38
1000 38
1100 37
1200 36
1300 36
1400 35
1500 34
1600 34
1700 33
1800 33
1900 32
2000 32
2100 31
2200 30
2300 30
2400 29
2500 29
2600 28
2700 28
2800 27
2900 27
3000 26
3100 26
3200 25
3300 25
3400 25
3500 24
3600 24
3700 23
3800 23
3900 22
4000 22
4100 22
4200 21
4300 21
4400 21
4500 20

A final haematocrit of 21 will result in an allowable blood loss of 4300 ml

..... Haematocrit (HCT)

Above applies to A MALE and MUSCULAR patient who weighs 75kg and has a starting haematocrit of 45 with an estimated blood volume of 5630ml.

Estimated Blood Loss (EBL)

100..26

200..25

300..25

400...24

500..23

A final haematocrit of 21 will result in an allowable blood loss of 800ml

600..................................22

700.............................22

800.........................21

900....................20

1000...............20

1100..........19

....Haematocrit (HCT)

Above applies to a MALE and THIN patient who weighs 50kg with a starting haematocrit of 27 and an estimated blood volume of 3250ml.

Estimated Blood Loss (EBL)

100 35

200 34

300 33

400 32

500 31

600 30

700 30

800 29

900 28

1000 27

1100 26

1200 26

1300 25

1400 24

1500 24

1600 23

A final haematocrit of 21 will result in an allowable blood loss of 1900 ml

1700 22

1800 22

1900 21

2000 21

2100 20

2200 19

..... Haematocrit (HCT)

Above applies to a FEMALE and NORMAL patient who weighs 55kg with a starting haematocrit of 36 and an estimated blood volume of 3580ml.

Estimated Blood Loss (EBL)

100 32

200 32

300 ... ...31 A final haematocrit of 27 will result in an allowable blood loss of 900 ml

400 30

500 30

600 29

700 28

800 28

900 27

1000 27

1100 26

1200 ... .26

... ... Haematocrit (HCT)

Above applies to a FEMALE and OBESE patient who weighs 85kg with a starting haematocrit of 33 and an estimated blood volume of 4680ml.

PATIENT INFORMATION AND CONSENT FOR HAEMODILUTION

The operation that you need will involve some loss of blood. This can either be replaced with blood donation by another person or with your own blood which we will take from you immediately before the operation starts.

Blood from another person involves some risk of allergic reactions and possibly infection, although every precaution is taken to minimise this. Your own blood is totally safe for you. If you agree to take part in this study we would take some of your blood from you before the operation and replace it with intravenous fluids. We would then return your blood to you as necessary during or after the operation.

If you would prefer not to take part in the study we will attempt to obtain donated blood for you in the usual way.

CONSENT

The above information has been explained to me and I fully understand and do hereby consent to be included in the study of Perioperative Haemodilution.

I also consent to any other form of blood transfusion e.g. screened homologous blood if the need arises.

FULL NAME: _____

SIGNATURE: _____

WITNESS: _____

DATE: _____

PERIOPERATIVE NORMOVOLAEMIC HAEMODILUTION IN MAJOR ORTHOPAEDIC OPERATIONS IN LUSAKA.

SURNAME:... ... ...FIRST NAME(S):... ... ...

ADDRESS:... ... ...

... ...

FILE NO.:... ... ...AGE:... ... ...SEX... ... ...

DIAGNOSIS:... ... ...

OPERATION:... ... ...DURATION... ... ...

DATE OF OPERATION:... ... ...SURGEON:... ... ...

HAEMOGLOBIN/HAEMATOCRIT (PRE OP):... ... ...

PREMEDICATION:... ... ...

AMOUNT OF BLOOD WITHDRAWN:... ... ...

PROBLEMS ENCOUNTERED DURING PHLEBOTOMY:... ... ...

... ...

ESTIMATED BLOOD LOSS DURING OPERATION:... ... ...

INTRAVENOUS FLUIDS USED (TYPE/QUANTITY):... ... ...

BLOOD LOSS FROM DRAIN:... ... ...

POST OP HAEMOGLOBIN/HAEMATOCRIT (72 HOURS):... ... ...

BLOOD TRANSFUSION (EXCLUDING AUTOTRANSFUSION):... ... ...

COMPLICATIONS:... ... ...

HAEMATINICS USED (POST OP):... ... ...

DATE OF DISCHARGE:... ... ...

HAEMOGLOBIN/HAEMATOCRIT AT TWO WEEKS (POST OP):... ... ...

BUDGET

1.	Single blood bags	-	K7,000 each
2.	Blood giving sets	-	K3,000 each
3.	Normal Saline (1 litre bags)	-	K5,000 each
4.	Haemogram	-	K3,000 each