Multimodal approach to blood conservation in the surgical patient

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Abstract

Allogeneic blood remains a scarce and expensive resource, even as the risks of disease transmission and other complications associated with blood transfusion are well known. Blood conservation, however, is a quality-of-care concept that transcends these and other known and unknown complications of transfusion, to involve a gamut of strategies meant to prevent exposure of patients to allogeneic blood. In urging a halt to incessant allogeneic blood transfusion, we report three cases to highlight the benefits of multimodal multidisciplinary collaboration in blood conservation. The three patients were chosen on account of either religious objection to any blood transfusion or the likelihood of exposure to several units of allogeneic blood. The blood conservation plan proposed for each patient was discussed with the respective surgeon and patient. Multimodal multidisciplinary approach to blood conservation utilising combination of strategies best suited for each individual patient will remarkably reduce the exposure of patients to allogeneic blood thereby ensuring better use of the scarce resource, and and preventing potential clinical complications and spiritual trespass of Jehovah's Witnesses.

Key words: Allogeneic, autologous, blood conservation, Jehovah's Witness, transfusion trigger

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Introduction

Blood conservation is a clinical concept that considers all strategies aimed at reducing patient exposure to allogeneic blood products. Prior to 1985, surgeons and anesthetists had insisted on a patient hemoglobin (Hb) level of 10 g/dl or more before surgery; with such mindset guiding intra-operative and post-operative transfusion practice. However the AIDS epidemic and strong advocacy by Jehovah's Witnesses have largely led to a paradigm shift in transfusion medicine in favour of tissue perfusion and oxygen delivery, rather than mere Hb levels. This new trend has got further support inin the finding that there was no difference in mortality and morbidity of fit patients till Hb levels fall below 7 g/dl.[1] Restrictive transfusion strategies utilizing lower transfusion triggers have actually been shown to be associated with lower mortality than liberal strategies. [2] Moreover in normal physiological states, oxygen delivery exceeds resting oxygen requirements by a factor of two to four.[3]

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Despite rigorous screening, inadvertent transmission of infectious diseases remains a significant cause of patient morbidity and mortality.[4] Noninfectious hazards include blood transfusion reactions, transfusion-related acute lung injury, immunomodulation, clerical errors in the blood bank, and misidentification of recipients. Furthermore, blood transfusion has independently been associated with increased morbidity and mortality in critically ill patients.[5]

Thus, the appropriateness of blood transfusion would be greatly enhanced by the adoption of restrictive transfusion strategy utilizing lower transfusion triggers that are individualized, as as there is no specific Hb level, below which patients require transfusion.[6]

The advent of artificial oxygen carriers represents the next level in blood conservation despite the drawbacks of their

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high cost, short circulatory half life, and toxicity. A number of perfluorocarbon emulsions and modified hemoglobin solutions have been undergoing clinical evaluation since Amberson[7] administered hemoglobin–saline solutions in clinical trials.

Case Reports

The blood conservation plan proposed for each case was discussed with the respective surgeon and patient, while the availability of essential materials and adjuncts were confirmed with the Blood Bank and Operating Room (OR) staff. The three patients were chosen on account of either religious objection to any blood transfusion or the likelihood of exposure to several units of allogeneic blood.

Patient A is a 50-year-old male civil servant who was scheduled for free radial forearm flap to cover a left leg ulcer sustained two years earlier from a motorcycle accident. He had undergone two previous surgeries under general anesthesia for the associated fractures of left tibia and fibula. There was no significant finding on examination. The full blood count, serum electrolytes, and electrocardiogram (EKG) were all normal. The packed cell volume (PCV) was 42% and he had in stock two units of pre-operative autologous blood donation (PAD) blood. Following discussion with the surgeon, the plan was to harvest a third unit of blood in the theatre prior to surgery using acute normovolemic hemodilution (ANH) technique and to use a hypotensive anesthesia technique to minimize intraoperative blood loss while achieving a "bloodless" surgical filed. In the OR, monitoring was instituted with Carl Novel® CN 90CT patient monitor and baseline values of noninvasive blood pressure (NIBP), heart rate (HR) and oxygen saturation (SpO_2) were 150/80 mmHg, 80 beats/minute, and 98% respectively. Electrocardiographical (EKG) monitoring was with lead II and continuous temperature monitoring was facilitated by a thermocouple probe firmly secured in the axilla. A 14 g cannula was used to collect one unit of fresh whole blood into a blood bag containing citrate-phosphate-dextrose-adenine. Lactated Ringers solution (1500 ml) was infused simultaneously through a 16 g cannula in the contralateral arm. Premedication was with intravenous atropine sulphate (1.2 mg) and diazepam (5 mg). General anesthesia with relaxant technique was established using propofol/isoflurane/pancuronium. Ketamine hydrochloride, in aliquots, was used for analgesia. A tourniquet was applied to the thigh of the recipient site. The surgery was undertaken by two plastic surgeons; one harvested the forearm free flap while the other prepared the recipient site. Electrocautery greatly facilitated the surgery. Intraoperative blood pressure was kept between mean arterial pressure (MAP) of 54 mmHg and 93 mmHg, except towards the end of the surgery when the surgeon requested an increase in perfusion pressure to identify anastomotic leaks after irrigating the vascular graft with heparin and lidocaine. An abdominal hypogastric flap was used to cover the resultant forearm defect. Anesthesia lasted 9 hours and and 52 minutes. Urine output was 850 ml. Additional intraoperative fluid included hydroxyethyl starch 6% (500 ml) and normal saline (500 ml). The ANH fresh whole blood was given intraoperatively. The estimated blood loss was 350 ml, and the PCV done two days post-op was 43%. The patient was discharged home 30 days after surgery.

Patient B is a 63-year-old painter with a subtrochanteric fracture of the left femur sustained from a fall off a scaffold two weeks prior to presentation at our hospital. He is a Jehovah's Witness and was scheduled for open reduction and internal fixation by angle blade plating. Preoperative history and examination revealed no abnormality. The serum electrolytess, urea and creatinine as well as fasting blood glucose were all within normal limits. The Hb estimation was 11.6 g/dl. The patient had a written order against transfusion of blood or blood product; even his own. He was subsequently commenced on high dose hematinics and subcutaneous injection of recombinant human erythropoietin (rHuEpo) 4000 IU, three times a week for two weeks before surgery and a week after surgery. Repeat hemogram, which was ordered 24 hours to the surgery, was not made available, but the surgery was allowed to proceed as scheduled. The anesthetist requested that two consultant orthopedic surgeons be available for the case as well as the provision of a functional Electrocautery Unit and bone wax. The anesthetic plan was to use regional technique with acute hypervolemic hemodilution(AHH). In the theater intravenous access was secured via a 16 g cannula. Routine monitoring was commenced including NIBP, HR, and SpO_2. Baseline values were 160/80 mmHg, 90/minute, and 97%, respectively. EKG monitoring was with lead II and continuous temperature monitoring was facilitated by a thermocouple probe firmly secured in the axilla. Following premedication with intravenous diazepam (10 mg) and fluid preloading with normal saline (1500 m1), a subarachnoid block was established with hyperbaric bupivacaine (17.5 mg) using a 23 g Quincke point spinal needle. A T-5 sensory block was established and the blood pressure ranged between 90/50 mmHg and 130/70 mmHg throughout the duration of the surgery which lasted two hours and 17 minutes. The urine output was 1000 ml, and blood loss was estimated at 1400 ml. The patient received a total of 1000 ml of colloid (Isoplasma) and 3500 ml of normal saline in the theatre. The hemogram done on the third post-operative dayday was 8.5 g/dl.

Patient C is a 40-year-old Jehovah's Witness with spinal stenosis secondary to prolapsed intervertebral disc scheduled for posterior spinal decompression. His past medical history included an appendectomy done over 20 years ago. The laboratory investigations showed normal fasting blood sugar, serum electrolytes, and

Table 1: Blood conservation strategies applied in each patient

Patient	Blood conservation strategies
A	PAD, ANH, hypotensive anesthesia, electrocautery, tourniquet, twotwo surgeons
B	Low 'transfusion trigger', rHuEpo, regional technique, AHH, electrocautery, bone wax, twotwo surgeons
C	AHH, hypotensive anesthesia, electrocautery, bone wax, local vasoconstrictor, twotwo surgeons, positioning

PAD=Preoperative autologous blood donation, ANH: Acute normovolemic hemodilution

creatinine. Hemoglobin estimation was 13.6 g/dl andand PCV was 39%. On examination, his general condition was satisfactory. Musculoskeletal system examination showed a "limping gait" on walking with decreased muscle bulk on the left thigh. Slight tenderness of the lumbosacral spine was elicited, but sensation was globally intact on both lower limbs. His vital signs were normal. The anesthetic plan was to use AHH with hypotensive general anaesthesia. Two consultant spinal surgeons were on hand with functional electrocautery unit, bone wax, and vasoconstrictor (adrenaline 1:80,000) for local infiltration.

In the Operating Room (OR), monitoring was instituted with Carl Novel® CN 90CT patient monitor and baseline values of the parameters were NIBP 130/90 mmHg (MAP = 101 mmHg), HR 81/minute, and SpO_2 99%. EKG monitoring was with lead II and continuous temperature monitoring was facilitated by a thermocouple probe firmly secured in the axilla. Intravenous access was secured with a 16 g cannula and hydroxyethyl starch 6% solution (500 ml) was infused over 15 minutes. Premedication with intravenous diazepam (5 mg) and atropine sulphate (1 mg) were administered. Following pre-oxygenation, general anesthesia with controlled ventilation was instituted and maintained with propofol/halothane/pancuronium bromide and pentazocine. Surgery was done in the prone position and lasted one hour and 35 minutes. MAP ranged between 56 mmHg and 91 mmHg intra-operatively. The estimated blood loss was 350 ml and urine output was 400 ml. Additional infusion of normal saline (1000 ml) was given during surgery. Surgery was uneventful and the surgeons described the operative site visibility as fantastic. The patient was reversed, log-rolled onto a trolley and extubated at the end of surgery. The PCV done two days after surgery was 37%, and the patient was discharged home 13 days after surgery.

Discussion

In all the three cases, multiple modalities of blood conservation were employed. Table 1 shows the strategies employed in each case. Each patient was managed with a cocktail of six, or more blood conservation strategies involving the anesthetist, surgeon, patient, and the blood bank.

Despite the availability of two units of stored PAD blood of Patient A, a further harvest of a third unit was facilitated by ANH in the OR in anticipation that the long duration of the vascular surgery may be associated with remarkable blood loss. The two units of stored PAD blood of patient A were not eventually transfused into the patient, as the scanty blood loss encountered during the surgery obviated the need for such exercise. Blood should not be transfused simply because thethe patient's own blood is available. PAD blood service involves collection, clerical duty, screening, storage, typing, and cross-matching and some guidelines recommend that the same criteria be applied to the use of such autologous blood as for allogeneic blood in view of reported administrative errors and bacterial contamination.[8] He received only the ANH blood.

Patient B is a Jehovah's Witness and would not accept either ANH or PAD, owing to his strong religious conviction against transfusion of whole blood or any of its primary components red cells, white cells, platelets, and plasma.[9] He had AHH which is simple, time and cost-effective, requiring no equipment, and could be as efficacious as ANH.[10,11] Recombinant human erythropoietin (rHuEpo) was used to increase his red cell mass with the cost of the three-week therapy put at about N60,000 (US $400). Such a cost profile, modest as it were owing to the limited dose and duration of the therapy, has mitigated rHuEpo availability and usage in resource-poor environments. Despite its efficacy in reducing the need for allogeneic transfusion, it is not cost effective when compared to other modalities of blood conservation, or allogeneic blood procured at N6,000 (US $40) per unit. It, nevertheless, serves a niche among renal failure patients and Jehovah's Witness.

Patient C, also a Jehovah's Witness, had AHH among other blood conservation strategies for his spinal surgery. Blood loss was minimal while the surgical field was 'dry'.

Hourly urine output was monitored closely in all the patients as an index of vital organ perfusion which is a critical consideration in patients undergoing hypotensive anesthesia. In all the three cases, two surgeons performed the surgery as a way of minimizing blood loss through enhanced surgical skill, dissection, tissue handling, hemostasis, and shortened surgical time.

Logistic constraints included the inability to have invasive blood pressure (IBP) monitoring and accurate hourly measurement of urine output using a measuring graduated glass cylinder. Core temperature monitoring was unavailable too. Non-availability of potent opioid analgesics and nitrous oxidenitrous oxice (N_2O) compelled the use of ketamine for analgesia despite its well-known sympathetic cardiovascular effects.

Blood conservation may be achieved by increasing the patient's Hb reserve, thereby making him able to tolerate blood loss better through measures such as the treatment of infections and nutritional disorders, and minimizing blood loss from diagnostic testing. Intraoperative blood loss can be reduced by meticulous surgical technique, posture, use of antifibrinolytic agents, vasoconstrictors, and local hemostatic agents, tourniquet for limb surgeries, electrocautery, laser, argon beam coagulation, andand ultrasonic scalpel among others. Minimally invasive surgery (e.g. laparoscopy, arthroscopy), staging of complex procedures, and regional and hypotensive anesthesia have all been associated with reduced surgical blood losses.

'Elective hypotension', first used in 1917, by Harvey Cushing[12] to achieve a 'bloodless' field during neurosurgery has proved very useful in reducing surgical blood loss and improving surgical site visibility with reduction of surgical time in selected cases such as spinal surgery,[13] total hip arthroplasty,[14] plastic,[15] middle ear,[16] and orthognathic procedures.[17] Though mean arterial pressure (MAP) of 50-60 mmHg (or 30% reduction from baseline value) is thought to provide adequate critical perfusion of vital organs in normal situations, the influence of anesthetic agents on the autoregulatory mechanisms and varying patient factors make fixation to these figures unrealistic and treacherous. Little and Hampton[18] recorded high morbidity and mortality with very low target blood pressure (BP). Target MAP should be individualized, and determined by that which is required to achieve the 'bloodless' field with duration limited to the part of the surgical procedure deemed to benefit from it. Despite some reservation about its safety,[19] elective hypotension (= hypotensive anesthesia) is sometimes a very necessary technique. Enderby[20] had reported nine deaths in a series of 9107 hypotensive anesthetics. The deaths occurred during or after surgery as a result of anesthesia, surgery, both, or unexplained causation even with the modest monitoring available six decades ago. Appropriate patient selection and monitoring by an experienced anesthetist are mandatory for safe and good outcome.

Prevention of coagulation failure by preoperative diagnosis and correction of clotting deficiencies as well as prevention of hypothermia all result in reduced intra-operative blood loss. Various options also exist for the use of autologous blood in blood conservation and include PAD, ANH, AHH, and autologous blood salvage**.**

Recombinant human erythropoietin (rHuEpO) which stimulates the bone marrow to increase red cell mass has been widely used independently to increase Hb level and enhance the ability to tolerate blood loss, or as an adjunct to increase the harvest of autologous blood during PAD and ANH. Besidess its high cost, its use requires a few weeks for optimal response and may sometimes be complicated by hypertension and thromboembolic events.

Conclusion

Multimodal approach to blood conservation in the surgical patient with involvement of the patient, anesthetist, surgeon, Blood Bank, and hematologist is an essential and safe quality-of-care issue beyond the cost and safety of allogeneic blood. The techniques for each patient should be individualized, with consideration for safety, efficacy, simplicity, cost-effectiveness and spiritual well-being of the whole person.

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