

Patient blood management for cardiovascular surgery: Clinical practice consensus statement

Ashish Govinda Amatya¹, Apurb Sharma², Battu Kumar Shrestha¹, Bipin Nepal³, Hem Raj Paneru⁴, Amit Shrestha⁵, Ravi Baral⁶, Arjun Gurung⁷, Nirmal Panthee⁸, Ajay Gandhi⁹, Klaus Goerlinger¹⁰, Diptesh Aryal¹¹, Lalita Shakya⁸, Chandra Mani Adhikari¹², Bishesh Poudel¹³, Bijoy G Rajbanshi¹⁴

¹ Department of Anesthesiology, Shahid Gangalal National Heart Center, Kathmandu, Nepal

² Department of Anesthesiology and Pain Management, Nepal Medicit, Lalitpur, Nepal

³ Department of Research, Tribhuvan University Lions Blood Transfusion and Research Center, Kathmandu, Nepal

⁴ Department of Critical Care Medicine, Tribhuvan University Teaching Hospital, Kathmandu, Nepal

⁵ Department of Hematology, Nepal Cancer Hospital & Research Centre, Lalitpur, Nepal

⁶ Department of Cardiothoracic and Vascular Surgery, Manmohan Cardiothoracic Vascular and Transplant Center, Kathmandu, Nepal

⁷ Department of Cardiac Anesthesiology, Manmohan Cardiothoracic Vascular and Transplant Center, Kathmandu, Nepal

⁸ Department of Cardiac Surgery, Shahid Gangalal National Heart Center, Kathmandu, Nepal

⁹ Department of Clinical Affairs, Instrumentation Laboratory India Pvt Ltd

¹⁰ TEM Innovations/ Werfen PBM, Munich, Germany

¹¹ Nepal Intensive Care Research Foundation, Kathmandu, Nepal

¹² Department of Cardiology, Shahid Gangalal National Heart Center, Kathmandu, Nepal

¹³ Department of Clinical Hematology and Bone Marrow Transplant Unit, Civil Service Hospital, Kathmandu, Nepal

¹⁴ Department of Cardio Vascular and Thoracic Surgery, Nepal Medicit, Lalitpur, Nepal

Corresponding Author: Dr Ashish Govinda Amatya

Department of Anaesthesia, Shahid Gangalal National Heart Centre, Kathmandu, Nepal

Phone: +977-1-4371322

Email: amatyaashish151@gmail.com

ORCID ID NO: 0000-0002-8370-9511

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Abstract

Anemia, blood loss and transfusion related issues following cardiovascular surgery are detrimental to patient outcomes. This document provides a concise overview of the Patient Blood Management for Cardiovascular Surgical Practice in Nepal. The consensus aims to optimize patient outcomes and enhance the quality of care in cardiovascular surgery by emphasizing evidence-based approaches to blood management. The document covers a range of topics, including preoperative assessment, intraoperative strategies, and postoperative care, with a focus on minimizing unnecessary blood transfusions, promoting hemostasis, and reducing the risk of complications. By adhering to this consensus, healthcare professionals can contribute to improved patient safety and overall clinical effectiveness in the field of cardiovascular surgery.

Keywords: Cardiac Surgery, Consensus, Blood transfusion, Patient Blood Management

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Background

Patient blood management (PBM) is a patient-centered, multimodal and multidisciplinary approach to improve patient outcome by reducing unnecessary transfusion of blood and blood products. It goes beyond a conventional "Restrictive transfusion strategy" and commences long before the need for transfusion arises and provides comprehensive care to patients from the pre-operative stage through the postoperative period, optimizing modifiable risk factors that could otherwise lead to transfusion. The concept of PBM is also applicable to non-surgical cases with potential risk of requiring blood transfusion. The WHO published policy brief to implement PBM in 2021 to create a sense of urgency for health care centers throughout the world.¹ In 2022 European Society of Cardiology (ESC) guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery states that in patients undergoing surgery with expected blood loss of $\geq 500\text{mL}$, use of washed cell salvage is recommended. It is also recommended to use point-of-care (POC) diagnostics for guidance of blood

component therapy, when available.² Recently, National Institute for Health and Care Excellence (NICE) published guidelines for blood transfusion which have incorporated many features of the PBM strategy including the alternatives to blood transfusion, active measures to reduce perioperative blood loss and the appropriate management of postoperative anemia (Table 1).³ PBM focuses upon three pillars of care: optimization of red cell mass and erythropoiesis before operation, minimization of blood loss, and management of postoperative anemia and optimization of patients' tolerance to anemia (Figure 1).

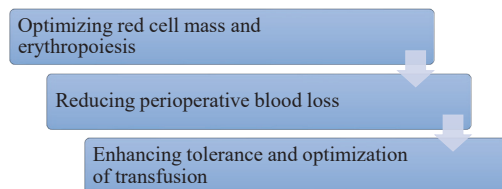


Figure 1: Three pillars of PBM

Implementation of PBM requires multidisciplinary involvement, and often needs an organizational change, to facilitate these interventions. This consensus summarizes PBM and the strategies involved in identifying and managing perioperative anemia and blood transfusion for cardiovascular surgery.

Table 1: Summary of recommendations NICE guidelines blood transfusion³

Alternatives to blood transfusion for patients having surgery	<ul style="list-style-type: none"> • Offer oral iron in iron deficiency before and after surgery • Offer Tranexamic acid (TXA) in surgery expected to have >500ml blood loss • Consider cell salvage with TXA if high volume blood loss expected
RBCs	<ul style="list-style-type: none"> • Consider a threshold of 7.0 g/dL and a target of 7.0-9.0 g/dL after transfusion when using restrictive red blood cell transfusions • Consider single-unit red blood cell transfusions for adults who do not have active bleeding
Platelets	<ul style="list-style-type: none"> • In patients not bleeding or not having an invasive procedure or surgery: Offer prophylactic platelets with platelet count below 10,000/mm³ and who do not have: <ul style="list-style-type: none"> ◦ Chronic bone marrow failure ◦ Autoimmune thrombocytopenia ◦ Heparin-induced thrombocytopenia ◦ Thrombotic thrombocytopenic purpura • Do not routinely transfuse more than a single dose of platelets
Fresh frozen plasma (FFP)	<ul style="list-style-type: none"> • Only consider FFP with clinically significant bleeding if coagulation tests are abnormal e.g., Prothrombin time ratio, Activated partial thromboplastin time ratio >1.5 • Do not offer FFP to correct abnormalities in coagulation in patients who: <ul style="list-style-type: none"> ◦ Are not bleeding (unless having a procedure with a risk of significant bleeding) ◦ Require reversal of vitamin K antagonist

Prothrombin complex concentrate (PCC)	<ul style="list-style-type: none"> • Offer immediate PCC for the emergency reversal of warfarin anticoagulation in: <ul style="list-style-type: none"> ◦ severe bleeding or ◦ head injury with suspected intracerebral hemorrhage
Cryoprecipitate	<ul style="list-style-type: none"> • Consider cryoprecipitate for patients with clinically significant bleeding and fibrinogen <1.5 g litre⁻¹ • Consider prophylactic cryoprecipitate for patients with fibrinogen level <1.0 g litre⁻¹ who are having invasive procedures or surgery with a risk of bleeding • Use 2 pools of cryoprecipitate and reassess the clinical condition
Patient safety	<ul style="list-style-type: none"> • Monitor for acute blood transfusion reactions • Consider using electronic identification systems to improve safety and efficiency during the blood transfusion process
Patient information	<ul style="list-style-type: none"> • Provide verbal and written information to patients who may have a transfusion explaining: <ul style="list-style-type: none"> ◦ the reason for transfusion ◦ the risks and benefits ◦ the transfusion processes ◦ specific transfusion needs ◦ alternatives to transfusion ◦ that they are no longer eligible to donate blood ◦ that they are encouraged to ask questions

Importance of PBM in cardiac surgery

PBM is crucial in cardiac surgery for following reasons:

1. Reducing Blood Transfusions: PBM aims to minimize the need for blood transfusions, which carry inherent risks. By implementing strategies such as preoperative anemia management and intraoperative blood conservation techniques, the reliance on transfusions can be decreased.⁴
2. Enhancing Patient Outcomes: Lowering the use of blood transfusions can lead to improved patient outcomes, reduced complications, and shorter hospital stays after cardiac surgery.
3. Lowering Costs: Implementing PBM strategies can help reduce healthcare costs associated with blood product usage, hospital stay, and treatment of transfusion-related complications.⁵⁻⁶
4. Preserving Blood Supply: PBM contributes to conserving the limited blood supply and ensures that blood products are available for patients who truly need them, such as those with

severe anemia or bleeding disorders. Shrinking blood donor pools puts a strain on the blood supply system and may result in cancellation or postponement of elective surgery in some countries.⁷

- Decreasing Risks: Blood transfusions carry potential risks, including, but not limited to infections, allergic reactions, transfusion-related acute lung injury (TRALI) and transfusion associated circulatory overload (TACO). By minimizing transfusions, these risks can be mitigated.
- Tailoring Treatment: PBM involves personalized care for each patient, considering their individual needs and medical history, leading to more effective and safer treatment plans.

Overall, implementing PBM protocols in cardiac surgery can result in improved patient safety, better clinical outcomes, reduced healthcare costs, and a more sustainable use of blood resources. Post implementation monitoring is also essential to apply quality assurance measures of good benchmarking, continuous monitoring and feedback.⁸

Methods

The process used to develop the consensus document involved several steps, including participant selection, information gathering and analysis, and criteria for making recommendations.

Participant Selection:

In April 2022, the executive committee of cardiac society of Nepal nominated Dr Apurb Sharma as the chairman of the writing committee for a consensus document on patient blood management in cardiovascular surgery. Dr Sharma invited Dr Ashish Amatya as the co-chair of the committee and selected committee members to write the Patient Blood Management consensus document. The meetings of the PBM task force were held online on 15th October 2022 and in-person on 2nd November 2022. The participants were selected based on their expertise in perioperative cardiac care, anemia management, and related fields. The task force comprised healthcare professionals, including cardiac surgeons, anesthesiologists, hematologists, perfusionists and other relevant specialists.

Information Gathering and Analysis:

The expert group reviewed relevant literature, guidelines, and protocols related to patient blood management in cardiac surgical patients. They also shared their own experiences and expertise in managing anemia in perioperative setting the Nepalese context. The information was gathered through literature reviews, expert opinions, and discussions among the participants.

Criteria for Making Recommendations:

The recommendations were made based on the best available evidence, consensus among the participants, and consideration of the local context and more importantly resource constraints. The criteria for making recommendations included the strength of the evidence, the potential benefits and harms of each intervention, and the feasibility and acceptability of the interventions in the Nepalese context.

Recommendation of the task force:

Pre-operative strategies

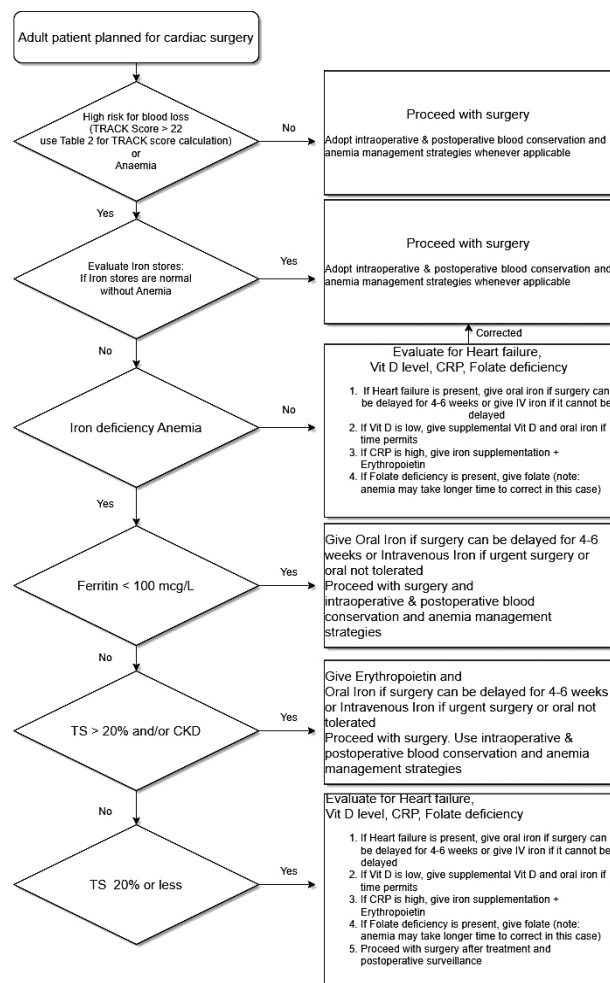
Anesthesiologist, surgeon, perfusionist, cardiologist, hematologist and the hospital administrator must be involved in the decision-making process for the benefit of the patient.

Following preoperative measures should be implemented:

1. Management of Anemia

In elective surgical procedure, it may be appropriate to delay an elective procedure when there is reversible cause of anemia or coagulopathy that can be corrected in a reasonable period of time.

According to the WHO, mild anemia is defined as Hb < 12 g/dL for women, Hb < 13 g/dl for males and severe Hb < 10 g/dL for both genders.⁹ The treatment of preoperative anemia and iron deficiency should commence as early as possible, ideally as soon as the decision to undertake surgery is made. When Iron Deficiency Anemia (IDA) is detected early, oral iron supplementation is usually the first-line treatment. Some side effects from the use of oral iron include nausea, constipation and vomiting.¹⁰⁻¹¹



CRP = serum C-reactive protein, Hb = hemoglobin, TS = transferrin saturation, EPO = Erythropoietin.

Figure 2: Algorithm for anemia management in the cardiac surgical population

Iron therapy

Iron supplementation should be done in anemic iron deficient patients scheduled for major surgery in next 4-6 weeks.¹² Intravenous iron is preferred over oral iron therapy. The dose of parenteral iron required to achieve the target Hb is usually between 1000 - 1500 mg and can be calculated from Ganzoni formula.¹³

Ganzoni formula

- Total iron dose (mg iron) = body weight (kg) × [target – initial hemoglobin g/dL] × 2.4
- Addition of 500 mg for iron stores

With suitable dosage of parenteral iron, an increase in Hb of 1–2 g/dL in 2–4 weeks may be expected.¹²

Recommendations

- Parenteral
 - Intravenous iron sucrose 200 mg twice a week till the deficit is corrected.
 - Intravenous ferric carboxymaltose (FCM) 1 gm till the deficit is corrected. It may be administered by intravenous injection using undiluted solution up to a maximum single dose of 1,000 mg iron (up to a maximum of 20 mg iron/kg body weight). For doses greater than 200 and up to 500 mg iron, it should be administered at a rate of 100 mg iron/min. For doses greater than 500 and up to 1,000 mg iron, it should be administered over 15 minutes. Do not administer more than 1,000 mg of iron per week.
- Oral - tablet elemental iron 60mg per oral on alternate day for one-month in empty stomach.
- Patients taking proton pump inhibitors (PPI) should receive iron tablets half an hour before and 4 hours after.
- If the patients do not tolerate the oral therapy, switch to intravenous therapy.

Erythropoietin (EPO)

Erythropoietin with iron supplementation should be considered to reduce post-operative transfusion in patients with non-iron deficiency anemia (e.g., EPO, vitamin D or folate deficiency) undergoing elective cardiac surgery.¹⁴

Recommendations

- Injection Erythropoietin alfa 150 U/kg subcutaneous two days apart and follow up after one month if the surgery can be delayed for 4-6 weeks.
- If surgery cannot be postponed for 4-6 weeks, single dose Erythropoietin Alfa 500U/kg with intravenous iron sucrose 200mg along with folic acid 5 mg per oral and vitamin B12 1 mg subcutaneous can be given prior to cardiac surgery.¹⁵

2. Coagulation and Antithrombotic Treatment

Thorough assessment of coagulation disorder should be done with history and physical examination. For all elective cardiac surgery, ticagrelor should be withdrawn preoperatively for a minimum of 3 days, clopidogrel for 5 days and prasugrel for 7 days. In patients with warfarin therapy, bridging should be done with unfractionated heparin or low molecular weight heparin. Laboratory and/or point-of-care measurement of antiplatelet drug effect in patients having received recent dual-antiplatelet therapy can be useful to assess bleeding risk or to guide timing of surgery if available.¹⁶

3. Transfusion risk assessment for patients undergoing cardiac surgery

Assessment of transfusion risk for patients undergoing cardiac surgery is crucial for ensuring patient safety and improving surgical outcomes. Clinical factors that indicate increased risk of bleeding are prior bleeding history, anticoagulant and antiplatelet medications, comorbidities like liver or kidney disease (Figure 3).

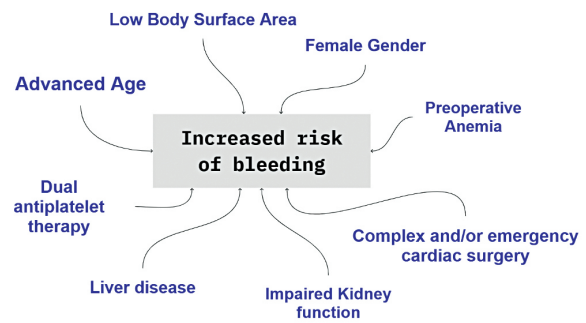


Figure 3: Patient related factors associated with increased risk of bleeding

(Adapted from: Meesters MI, Boer C. Definition and risk factors of bleeding. In: Heyman CV, Boer C, editors. Patient Blood Management in Cardiac Surgery. 1st ed. Switzerland: Springer Nature; 2019. p. 15 - 24. <https://doi.org/10.1007/978-3-030-15342-7>)¹⁷

There are several risk scores and predictive models proposed to estimate risk of transfusion in cardiac surgery with variable predictive power¹⁸⁻²⁵. Amongst the proposed risk scores TRACK (AUC 0.71) and TRUST (AUC 0.80) have acceptable predictive power and can be used for assessment of transfusion risk. The TRACK score was developed and validated in aprotinin-free environment in contrast to TRUST.²² The clinical usefulness of the TRACK is based on the possibility to identify patients at higher risk for receiving transfusions, and therefore to apply possible specific strategies to decrease this risk. However, it should be noted that using TRACK score alone may not be sufficient to exclude risk of perioperative transfusion.

Table 2 : TRACK Scoring System (Adapted from Ranucci et al.)²³

Patient Characteristic	TRACK Score (Points)
Age > 67	6
Weight < 60 Kg (female) or < 85 Kg (male)	2
Female Gender	4
Complex Surgery (2 or more combined cardiac procedures)	7
Hematocrit (% Hct)	40 minus patients' Hct (%) (up to 13 points)
Total	0 – 32

Note: The TRACK score is based upon 4 dichotomous scores and 1 continuous score (e.g., a 68 - year- old patient receives 6 points for age, whereas a 67- year- old patient receives 0 points). Patient's Hematocrit (Hct) score is continuous (e.g., if the patient's Hct is 29%, s/he would receive 40 - 29 = 11 points).

1. The score ranges from 0 to 32. A score of > 22 predicts high transfusion risk
2. The higher score indicates higher risk of perioperative transfusion.
3. Interpretation:²⁶
 - TRACK Score > 22 92% risk of receiving a transfusion
 - TRACK Score < 6 31% risk of receiving a transfusion
 - TRACK Score 6 - 22 31-92% risk of receiving a transfusion
 - TRACK Score 0 21% risk of receiving a transfusion

Preoperative patient blood management for cardiac surgery

- Perform lab test if expected blood loss > 500 mL or high transfusion risk or TRACK Score > 22
- Consider intravenous iron supplementation if an absolute iron deficiency is present irrespective of the presence of anemia.
- Consider intravenous iron supplementation in case of anemia due to inflammatory disease and chronic heart failure.
- Consider EPO and iron supplementation in case of anemia due to chronic renal failure
- Perform a hemostatic evaluation with history and physical examination.
- Discontinue anticoagulant drugs.

Intraoperative strategies

A team of anesthesiologists, cardiac surgeon and perfusionist should actively participate in the process intraoperatively. Following strategies are recommended:

1. Antifibrinolytics

International guidelines recommend prophylactic administration of antifibrinolytic agents in patients undergoing high-risk cardiac surgical procedures.²⁷ Commonly available drug in our country is tranexamic acid (TXA). Tranexamic acid can be given as a bolus or infusion or both. Recommended dose of tranexamic acid varies from 10mg/kg bolus to 100mg/kg bolus.²⁸ Also infusion dose varies from 1mg/kg/hour to 5mg/kg hour.²⁹

Recommendations

- Bolus dose of tranexamic acid of 30 to 50 mg/kg before incision for all cardiac surgeries.
- For high bleeding risk surgeries, bolus followed by infusion of 1 to 5mg/kg/hour till surgery is over.
- Infusion dose may be continued in post operative period if required.
- Additional bolus dose of tranexamic acid (20 to 30 mg/kg) can be given if there is ongoing medical bleed and POC viscoelastic test report shows hyperfibrinolysis.

High bleeding risk cardiac surgeries

- Redo surgery
- Emergency surgery
- Aortic surgery
- Combined surgery (e.g., Valve plus CABG)
- Surgery with prolonged CPB time

2. Pre-operative Autologous blood donation³⁰⁻³³

A pre-operative autologous blood donation (PABD) is when patient's blood drawn or collected before a scheduled surgery so that it can be re-transfused if needed. It can be used for patients with rare blood groups, multiple allo-antibodies or religious objections to allogeneic transfusion. The time interval between first blood donation and surgery varied between 2-4 weeks depending upon the unit of blood to be withdrawn. Adequate time interval is crucial for the red blood cell (RBC) regeneration of donated blood.

Pre-operative autologous blood donation (PABD)

- Blood is collected from the patient prior to the elective surgery.
- Amount: 300-450 ml can be withdrawn at a time.³¹
- Frequency: 2- 4 donation with at least 1 week apart and should be done 72 hours before surgery.³⁰
- Consideration of the routinely iron supplement to the patient should be done.^{31,32,33}
- 800 ml of pre-donation of the blood seems to be sufficient to avoid allogeneic blood transfusion in cardiac surgery. Approx. 1200 ml is desirable in case of re-do cases.

3. Autologous blood transfusion

Blood is drawn or collected before or during a scheduled surgery so that it can be transfuse back to the same person after procedure is over. Whole Blood is collected into standard blood bag before heparinization of the patient and the patient's blood volume is maintained by replacing crystalloid or colloid fluids.

Acute normovolaemic hemodilution

- Amount: approximately 15-20 ml/kg is withdrawn
- The blood is then stored in the operating theatre at room temperature and reinfused at the end of surgery or if significant bleeding occurs.
- Advantage: immediate postoperative transfusion of 'fresh whole blood' containing platelets and clotting factors is seen as an advantage.
- Prerequisite: pre donation Hb more than 13mg/dl
- Contraindication: unstable patients with high inotropes, critical left main disease, severe LV dysfunction.

4. Cell salvage

In this procedure blood is collected from suctioning of operative field, surgical drains or both and transfused back to the patient after filtration or washing. It can be done intraoperatively and postoperatively. The collected units of packed red blood after washing in cell saver machine is labeled and kept with the patient and is not refrigerated. It is transfused back to the patient in the postoperative period within 4 hours of processing. It is widely used in both elective and emergency surgeries with significant blood loss. It has shown a 20% reduction in donor blood exposure.³⁴

5. Retrograde autologous priming (RAP) of the CPB circuit.

In this 500-1000ml of blood is withdrawn from patient to prime the CPB circuit replacing prime crystalloid fluid. It's important to note that the use of retrograde autologous priming may vary depending on the specific surgical technique, patient condition, and surgeon preference.

Type of surgery where RAP is not recommended

- Hemodynamically unstable patient
 - Severe Aortic Stenosis
 - Cardiogenic shock
- Redo case
- Emergency cases
- Child below 15 kg

6. Miniaturized circuit.

A miniaturized circuit in cardiopulmonary bypass (CPB) refers to a modified or scaled-down version of the traditional CPB circuit used during cardiac surgery. The primary purpose of a miniaturized CPB circuit is to reduce the contact between blood and foreign surfaces, decrease the priming volume, and potentially minimize the adverse effects associated with conventional CPB.

Recommendation

We recommended to use miniaturized CPB circuit whenever possible.

7. Ultrafiltration using Hemo-concentrator

Ultrafiltration using hemo-concentrator is a technique commonly employed during cardiopulmonary bypass (CPB) procedures in cardiac surgery. It involves the removal of excess fluid, electrolytes and inflammatory mediators from the patient's blood. Excess fluid can be accumulated due to the dilutional effects of the CPB circuit's priming solution and the inadvertent administration of intravenous fluids. Ultrafiltration helps maintain proper blood composition and can have various physiological benefits for the patient.

Recommendations for ultrafiltration

- Excess reservoir volume when we have more than 1 liter.
- Prolong bypass time more than 180 minutes.
- Patients undergoing cardiac surgery with acute and chronic renal failure.
- Clinical evidence of excess body water like peripheral oedema.

8. POC hemostasis testing

Goal directed transfusion algorithms that incorporate point-of-care testing, such as with viscoelastic devices, are recommended to reduce perioperative bleeding and transfusion in cardiac surgical patients. This real-time information helps guide decisions about blood product transfusions, clotting factor administration, and other interventions to prevent bleeding or thrombotic complications.³⁵

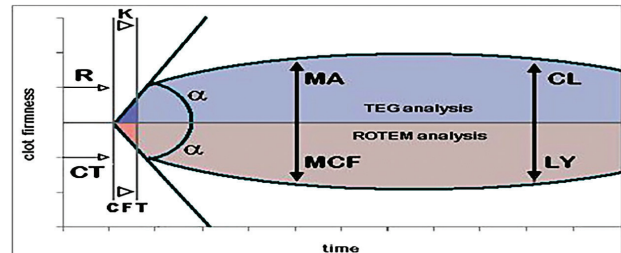
Before its institution, clinicians should be made aware of the algorithm and its objectives during educational rounds starting approximately 2 months before institution of the algorithm. Decisions regarding the use of components are guided by anesthesiologist/ cardiac surgeon /physician assigned to the case in operating room / intensive care unit.

POC should be considered in the following situations;

1. At the discretion of attending physician with presumption of medical bleeding 10-15 minutes after giving protamine. Thereafter the result of POC coagulation testing will be guided by the algorithm in figure 2 and 3³⁵
2. In complex cardiac surgery (valve-CABG, thoracic aortic surgery, aortic dissections, especially requiring deep hypothermic circulatory arrest), pre operative thrombocytopenia (Platelet count <100,000/mm³), coagulopathy (PT/INR >1.5) and CPB time more than 180 minutes at aortic decamping.
3. In intensive care unit, at the discretion of attending physician with presumption of the medical bleeding with the following clinical criteria;
 - i. Drop in hemoglobin
 - ii. With multiple inotropes
 - iii. Blood loss from chest drains
 - iv. Radiological collection in the pleural and pericardial cavity.

Thromboelastography and Thromboelastometry

Thromboelastography (TEG®, Haemonetics Corporation, MA, USA) and Thromboelastometry (Rotational thromboelastometry - ROTEM®, TEM International GmbH, Munich, Germany) are advanced hemostatic tests that provide real-time insights into a patient's coagulation status. They measure the dynamics of clot formation and dissolution, helping clinicians diagnose and manage bleeding and clotting disorders more effectively. A composite TEG and ROTEM figure is given below.



TEG Parameter	Interpretation	Direction/Products
R Time	Reaction time – time to fibrin formation	Increased – FFP transfusion (10-15 mL/kg) if moderately prolonged and 15 – 20 mL/kg if highly prolonged
K Time	Kinetics – 2 to 20 mm of Amplitude	Increased – Cryoprecipitate 10-15 Units for moderately increased K time and 15-30 Units for severely prolonged K time or life-threatening bleeding
Alpha Angle	r/k slope of tracing – increase in thrombus strength, Fibrinogen concentration	Decreased – Consider cryoprecipitate but should be tailored to the patient's unique clinical circumstances, Clinicians may consider transfusion of 1 Unit per 10 kg body weight and repeat TEG
Maximum amplitude	Strength and stability of the thrombus	Decreased – Check platelets counts and consider Platelets transfusion 5-10mL per kg body weight and repeat TEG would be reasonable approach
LY30 and LY60 (fibrinolysis 30 or 60 min after MA)	Fibrinolysis	Consider Tranexamic acid 15-25 mg/kg single bolus dose in addition to the local protocol

If rotational thromboelastometry is available, following assays and parameters should be used to enhance coagulation management. These assays and parameters include:

INTEM (Intrinsically Activated Test without Heparin Neutralization): To assess intrinsic coagulation factors, including fibrinogen and platelet function, which play a crucial role in clot formation.

EXTEM (Extrinsically Activated Test with Heparin Neutralization): To evaluate the extrinsic coagulation pathway,

shedding light on factors like fibrinogen and platelets that influence overall clot formation.

HEPTEM (Intrinsically Activated Test with Heparin Neutralization): Enables to monitor and adjust anticoagulation when heparin is involved, assess heparin reversal by protamine (by INTEM/HEPTEM CT-ratio), ensuring precise management during surgery.

FIBTEM (Extrinsically Activated Test with Platelet Inhibition and Heparin Neutralization): To specifically address and correct fibrinogen deficiencies, a vital aspect of managing bleeding during cardiac procedures.

Relevant ROTEM Parameters are: clotting time (CT), clot formation time (CFT), alpha angle (α -angle), early clot firmness amplitudes (A5 and A10), maximum clot firmness (MCF), and lysis parameters (ML, LI30, LI45, and LI60) to gain a comprehensive understanding of the patient’s coagulation profile.

We recommend using the validated A5 algorithm on ROTEM:

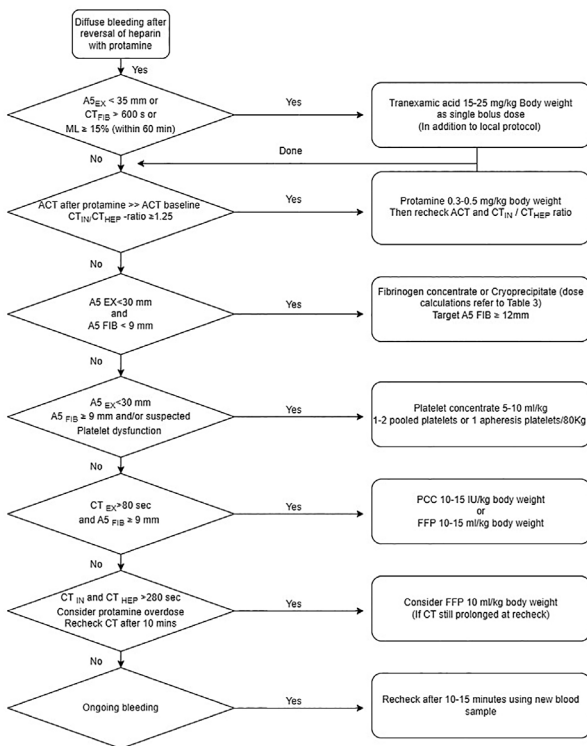


Figure3. Evidence-based algorithms for ROTEM (A5)-guided bleeding management in cardiovascular surgery³⁵

Table 3: FIBTEM-guided Fibrinogen Substitution

Targeted increase in FIBTEM A5 (A10) (mm)	Fibrinogen dose (mg/kg body weight)	Fibrinogen concentrate (ml/kg body weight)	Cryoprecipitate (ml/kg body weight)
2	12.5	0.6 (1 g per 80 kg)	1 (5 U per 80 kg)
4	25	1.2 (2 g per 80 kg)	2 (10 U per 80 kg)
6	37.5	1.9 (3 g per 80 kg)	3 (15 U per 80 kg)
8	50	2.5 (4 g per 80 kg)	4 (20 U per 80 kg)

10	62.5	3.1 (5 g per 80 kg)	5 (25 U per 80 kg)
12	75	3.8 (6 g per 80 kg)	6 (30 U per 80 kg)

A5: amplitude of clot firmness 5 min after CT, A10: amplitude of clot firmness 10 min after CT

Adapted from Gorlinger K et al. Korean J Anesthesiol 2019 August 72(4): 297-322³⁵

Intraoperative patient blood management for cardiac surgery ³⁶	
Optimize coagulation	Maintain body temperature > 36 C Maintain normal pH (7.35-7.45) and ionized calcium level (1.16 to 1.31 mmol/L) Use antifibrinolytics Avoid hemodilution, unnecessary blood sampling Use Cell salvage if available Consider point of care viscoelastic test.
CPB management	Consider minimally invasive extracorporeal circuits (MiECC) Consider autologous priming Consider ultrafiltration.
Surgical management	Consider Minimal invasive techniques Consider OPCABG over on-pump CABG in selected cases Avoid stagnation of shed blood in the chest cavity.

Post-operative strategies

Efforts to reduce bleeding, avoid coagulopathy and minimize blood loss should be continued into the postoperative period as well. Simple interventions to decrease iatrogenic blood loss reduce the incidence of anemia like reducing the frequency and volume of blood obtained for blood tests, particularly in the intensive care setting, can make a significant difference. Additional methods include a reduction in the sample volume (example using pediatric bottles), using continuous sampling lines with smaller dead space volumes (for arterial line samples) and evaluation of the requirement for each blood test according to clinical need.

The surgical stress response, inflammation and infection may precipitate functional iron deficiency in a similar manner to that of chronic disease. Consideration of replenishing iron stores should be made to reduce the incidence of postoperative anemia and improve functional capacity for rehabilitation in the similar fashion as it was done in preoperatively.

So, the postoperative strategies would be to maximize oxygen delivery, minimize oxygen consumption, avoid and treat infections promptly and most important is apply evidence-based transfusion thresholds.

Postoperative patient blood management in cardiac surgery³⁶

- Optimize oxygen delivery.
- Reduce oxygen consumption, optimal pain control, avoid tachycardia and hypertension.
- Continue to treat anemia.
- Consider Packed Red Blood cell transfusion only if Hb < 7 g/dl or Hct < 21% in a patient with ongoing blood loss with a target Hb of 8-9g/dL.
- Avoid unnecessary transfusion.

Clinicians may, however, consider blood transfusion in symptomatic anemia even if the Hemoglobin is higher than 7.0gm/dL. Symptomatic anemia is defined as the presence of at least one of the following symptoms or signs:

- Shortness of breath at rest or with exertion
- Chest pain or angina
- Confusion or decreased level of consciousness
- Dizziness or syncope
- Tachycardia (heart rate > 100 beats per minute)
- Hypotension (systolic blood pressure < 90 mm Hg)

Conclusions:

This consensus statement provides unified voice to guide clinician in the implementation of patient blood management in adult patient undergoing cardiovascular surgeries in Nepal. This consensus summarizes PBM and the strategies involved in identifying and managing perioperative anemia and blood transfusion for cardiovascular surgery.

Writing committee members

Chair: Dr Apurb Sharma

Co-chair: Dr Ashish Govinda Amatya

Members: Dr Battu Kumar Shrestha, Dr Bipin Nepal, Dr Hem Raj Paneru, Dr Amit Shrestha, Dr Ravi Baral, Dr Arjun Gurung, Dr Nirmal Panthee, Dr Ajay Gandhi, Dr Klaus Goerlinger, Dr Diptesh Aryal, Ms Lalita Shakya, Dr Chandra Mani Adhikari, Dr Bishesh Poudel, Dr Bijoy G Rajbanshi

Reviewers**Dr. Lakshman Edirisinghe**

Director, Head of WHO Collaborating Center
National Blood Transfusion Service, Ministry of Health, Sri Lanka

Dr. Namal Bandara MBBS, DTM, MD (Transfusion Medicine)

Consultant Transfusion Physician, Teaching Hospital Anuradhapura, Sri Lanka

Dr. Dhammika Senevirathne

MBBS, DTM, MD (Transfusion Medicine)
Consultant Transfusion Physician, Teaching Hospital-Anuradhapura, Sri Lanka

Dr. Rekha Manandhar Shrestha

Senior Consultant Pathologist, National Public Health Laboratory, Co-ordinator,
National Bureau for Blood Transfusion services, Teku, Kathmandu, Nepal

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Conflicts of interest

Author 9 is Associate Clinical Director, Instrumentation Laboratory India Pvt Ltd

Author 10 is Medical Director, TEM Innovations/ PBM Instrumentation Laboratory, Munich, Germany

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