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Review

Hemoglobin threshold and clinical predictors for perioperative blood transfusion in elective surgery: Systemic review

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ABSTRACT

Background: Lack of consensus on hemoglobin threshold and transfusion strategies have led to a wide variation in transfusion practices and inappropriate use of blood. This may result in over ordering of blood with minimal utilization or unnecessary allogenic blood transfusion. This may lead to financial crisis due to costs for blood handling, laboratory tests and blood administration. So, saving of blood and resources are required by rationalizing blood transfusion indications based on evidence-based hemoglobin threshold and clinical predictive factors in resource limiting setup.

Methods: Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocol was used to conduct this study. PubMed, Google Scholar and Cochrane Library search engines were used to find evidences that help to draw recommendations and conclusions.

Discussion: Half of clinical specialties used red blood cell transfusion with 7 g/dl threshold and the other half used 8 g/dl to 9 g/dl. Restrictive strategy of blood transfusion is as effective as liberal transfusion strategy in critically ill patients except in patients with cardiovascular diseases.

Conclusions: Transfusion is required at hemoglobin levels <7 g/dl. Recent guidelines and literatures have consistently expressed the transfusion threshold between 7 and 10 g/dl with clinical indicators further defining the need for allogenic transfusion in between.

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1. Introduction

Blood transfusion is a crucial component of patient care in surgical disciplines such as life-saving management [1]. This is usually done as a life-saving maneuver to replace blood cells or blood products lost through severe bleeding, during surgery when blood loss occurs or to increase the blood count in an anemic patients [2].

During the perioperative period, some patients may require transfusion of blood products. The most common cause and indication for administration of blood components is acute surgical blood loss and when the concentration of hemoglobin is low or the oxygen carrying capacity is reduced [3].

Blood transfusion is triggered for acute anemia secondary to; surgical hemorrhage (Hb $\leq$ 8 g/dl), traumatic hemorrhage (hemorrhagic shock, inadequate oxygen delivery), non-trauma and non-surgical hemorrhage(<7 g/dl), critical illness(<7 g/dl), early sepsis with inadequate oxygen tissue delivery(<9 g/dl), septic shock and late sepsis(Hg < 7 g/dl) and acute coronary syndrome with ischemia(Hb 8–9 g/dl) [4].

Current evidence shows that restrictive transfusion of blood is safe in stable post-operative and normovolemic critically ill patients with the trigger for transfusion being Hb of 7–8 g/dl or symptoms of anemia. Several factors contribute to anemia in critically ill patients. The most important factors are chronic disease, blood loss, increased red blood cell destruction, hemodilution and reduced red cell production with variable etiology. Determination of the cause of the anemia can impact perioperative surgical and medical management and outcome [4–6].

Blood transfusion related immunomodulation results in immunosuppresion, transfusion reaction, postsurgical cancer recurrence and an increased in predisposition to infectious diseases [7]. Carson et al. studied 110 patients with acute coronary syndrome with a mean age of 71 years and found fewer major cardiac events and deaths if red blood cell transfusion increased hemoglobin >10 g/dl compared to a restrictive strategy(10.9% VS 25.5%) [8]. Non-infectious serious hazards of transfusion have emerged as the most common complications of transfusion that includes mistransfusion, transfusion related acute lung injury, transfusion associated circulatory overload, post transfusion purpura and metabolic derangements [7–10].

The preoperative request of blood units, especially in elective surgery, is often based on the worst-case assumptions, demanding large quantities of blood or overestimating the anticipated blood loss, of which little is ultimately used. In South Africa, for example, 7–10% of blood is wasted annually because of over ordering of blood, India, Kuwait and Nigeria also showed utilization of blood 28%, 13.6% and 69.7% respectively [11]. Inappropriate use of blood may lead to financial crisis related with costs for blood bank handling, laboratory tests and blood administration [12].

Common variations in rates of transfusion may be due to many factors, including differences in opinions on the threshold level of hemoglobin below which patient needs blood transfusion, differences in surgical and anesthetic techniques, cancellation of cases, differences in case mix, preoperative anemia and lack of availability of transfusion protocols [13].

Lack of consensus on hemoglobin threshold and transfusion strategies have led to wide variation in transfusion practices and inappropriate use of blood. Therefore great saving of blood and resources are required by rationalizing blood transfusion indication based on evidence based hemoglobin threshold and clinical predictive factors in resource limiting setup [1].

Health care professionals commonly use hemoglobin concentration to decide when to transfuse. But there is variation in indication and initiation of transfusion between institution and among individual within the similar surgical procedure and clinical conditions due to many factors including different personal opinion of worst case assumption, hemoglobin value, estimation of blood loss, surgical techniques and lack of transfusion protocol [14].

Most guidelines stress that blood transfusion should not be only hemoglobin value alone, it should be considered the clinical sign/symptoms of anemia and the predictors of transfusion. So, the aim of this review is to support clinical decisions about perioperative blood transfusion by discussing the current evidences and indications for blood. Finally, this review will have some contributions in clinical decisions on perioperative hemoglobin threshold in patients scheduled for elective surgery at University of Gondar Comprehensive Specialized Hospital.

2. Methodology

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol was used to conduct this study (Fig. 1). For the development of this systemic review selection of appropriate search methods were conducted with PubMed, Google Scholar and the Cochrane database library. Systemic reviews, meta-analysis, guidelines, randomized controlled trials, systemic reviews of cohort studies and cohort studies were included in the review with the following terms “Blood Transfusion”, “Hemoglobin”, “Red Blood Cell”, “Transfusion”, “Trigger”, “Threshold”, “Strategy”, Liberal” AND “Restrictive” combined each other with Boolean operators (AND,OR). Appraisal and evaluation of the study quality with different institutional appraisal checklists were done to categorize evidences in to levels. Final conclusions and recommendations were done by balancing the benefits and downsides of the alternative strategies for hemoglobin threshold for perioperative blood transfusion in elective surgical patients. The level of evidences and recommendations were given based on good clinical practices of world health organization 2011(Table 1).

Studies done in emergency management of acute blood loss and researches on perioperative blood transfusion in pediatric surgeries were not selected to include in the current review.

3. Discussion

3.1. Haemoglobin transfusion thresholds and target

Traditionally, the rule of 10/30 was followed for blood transfusion to which Hb level of 10 g/dl or a hematocrit of 30% was recommended in surgical patients. Over the years, the trigger for transfusion has become more conservative or restrictive based on both laboratory value and objective clinical conditions of the patient’s age, co-morbidities, severity of illness and the rate and amount of hemorrhage [15]**1a**.

Preoperative anemia increases the likelihood of allogenic transfusion and should be investigated and where possible

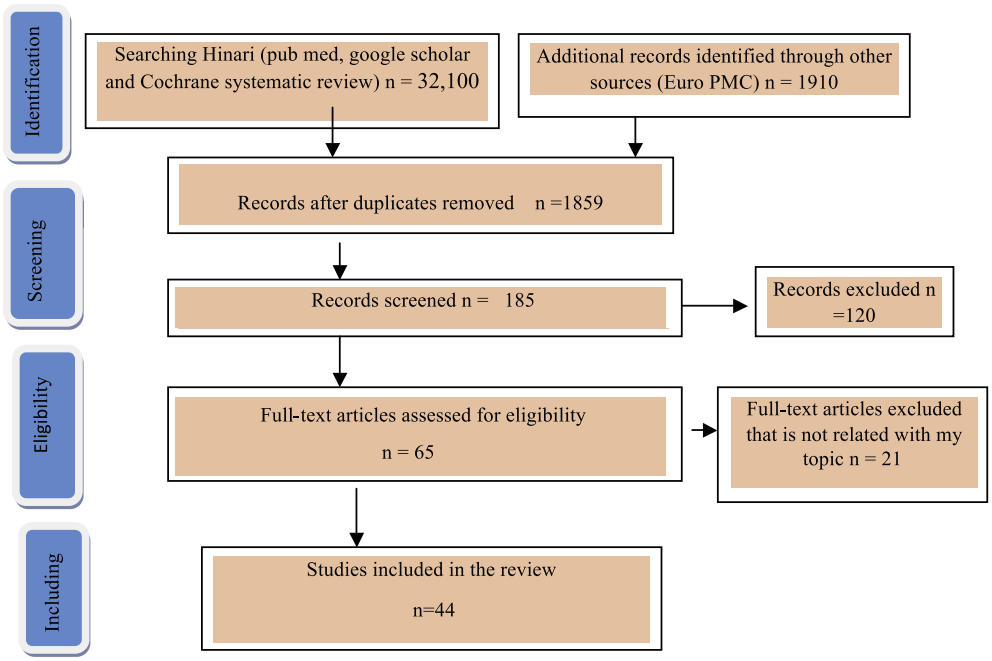

Fig. 1. PRISMA 2009 flow diagram.

Table 1
Level of evidences and recommendations.

Level	Type of evidences	Recommendations
1a	Meta-analyses, systematic reviews of randomized controlled trials, evidence-based guidelines	Strongly recommended/directly applicable
1b	Randomized clinical trials/Randomized controlled trials	Highly recommended/directly applicable
2a	Systematic reviews of case control or cohort studies.	Extrapolated evidence from other studies
3a	Non-analytic studies, e.g. Case reports, case series	Extrapolated evidence from other studies

corrected prior to major elective surgery. However, there is limited evidence available on appropriate preoperative hemoglobin concentrations. All patients undergoing major elective surgery should have proper history taking, physical examination and full blood count performed prior to surgery to avoid short term cancellation and to allow those patients presenting with anemia to be investigated and treated appropriately [3,6]**1b**.

In postoperative surgical patients, transfusion should be considered at hemoglobin concentration of 8 g/dl and with clinical symptoms (chest pain, orthostatic hypotension or tachycardia unresponsive to fluid resuscitation). In hemodynamically stable patients without pre-existing cardiovascular disease transfusion should be considered at a hemoglobin concentration of less than 7 g/dl and with clinical symptoms [2,16] **1a**.

When there is ongoing surgical blood loss, hemoglobin measurements should be interpreted in the context of a multifaceted clinical assessment, which should include clinical evaluation of blood volume status. There is no indication that thresholds should differ during this period but, the use of intraoperative transfusion must reflect the ongoing rate of surgical blood loss, continued hemodynamic instability and anticipated postoperative bleeding [17,18] **1a**.

Recent guidelines and consensus statements have consistently expressed the transfusion threshold as a range of hemoglobin usually between 7 and 10 g/dl, with clinical indicators further defining the need for allogenic transfusion in between. No evidence was found to suggest that cardiovascular function is improved blood transfusion at hemoglobin values > 10 g/dl [1,8] (**1a, 1b).**

A review of consensus statements supported lower limit of 7 g/dl and also suggested that patients with cardiovascular problems should have this limit raised to 8 g/dl. A large retrospective study of surgical patients confirmed that there was no difference in mortality using a lower threshold of either 8 or 10 g/dl. Transfuse one RBC unit at a time in hemodynamically stable, non-bleeding patients, with assessment of symptoms and post-transfusion Hb level prior to giving the next unit. Laboratory assessment of Hb may be performed as early as 15 min following blood transfusion [19] **1b**.

Transfusion is required at hemoglobin levels <7 g/dl. More evidence exists on which to base an upper limit for the transfusion range. A large randomized controlled trial done on patients of transfusion thresholds either on conservative (7–9 g/dl) or liberal (10–11 g/dl) threshold and no difference in 30 or 60-day mortality was found. In addition, there was no significance difference in severe ventricular dysfunction, with the overall mortality in this population [20] **1b.**

3.2. Liberal versus restrictive transfusion strategy

A meta-analysis of 3 studies done by Salpeter et al. showed that the restricting blood transfusions to patients whose hemoglobin is less than 7 g/dl leads to a significant reduction in total mortality, pulmonary edema, re-bleeding, and bacterial infection and compared with a more liberal transfusion strategy [21] **1a**.

A meta-analysis of 7 studies done by Franchini et al. identified that the transfusion of blood in normal hemoglobin concentrations does not improve organ failure and mortality in the critically ill patients. The studies recommended that restrictive transfusion strategy will reduce exposure to allogenic transfusions which

results in more efficient use of red blood cells, save blood overall and decreases health care cost [2] **1a**.

A systemic review of 31 studies done by Holist et al. revealed that there was a reduction in both the proportion of transfused patients and a reduction in the number of red blood cell units transfused in restrictive transfusion strategies when compared with liberal transfusion strategies but, mortality, morbidity and myocardial infarction seems to be unaltered. Generally the authors strongly recommended that restrictive transfusion strategies are safe in most clinical settings [15] **1a**.

A Meta-analysis of randomized trials done by Fominisky et al. stated about the perioperative mortality in adult patients either receiving a restrictive or liberal transfusion strategies [22]**1a**.

A Meta-analysis of 6 randomized controlled trials done by Ripolles et al. showed that in acute coronary syndrome, a restrictive hemoglobin transfusion threshold of 7 g/dl for hospitalized adult patients who are hemodynamically stable, including critically ill patients; but, a hemoglobin transfusion threshold of 8 g/dl for patients undergoing orthopedic or cardiac surgery and for those with underlying cardiovascular disease [19] **1a**.

A systematic review done by Carson et al. claimed that about half of clinical specialties used 7 g/dl threshold and the other half used 8 g/dl to 9 g/dl threshold. The studies concluded that restrictive transfusion strategies reduced the risk of receiving red blood cell transfusion by 43% across a broad range of clinical specialties [1]**1a**.

A meta-analysis of 11 randomized controlled trials done by Docherty et al. recommended not to use a restrictive transfusion threshold of less than 8 g/dl in patients with ongoing acute coronary syndrome or chronic cardiovascular diseases. These data support the use of a more liberal transfusion threshold (>8 g/dl) for patients with both acute and chronic cardiovascular disease until adequately powered high quality randomized trials have been undertaken in patients with cardiovascular diseases [23] **1a**.

A systematic review done by Hovaguimain et al. described cautiously to use restrictive transfusion strategies in high-risk patients undergoing major surgery [24] **1a**.

Among total of 921 patients with severe acute upper gastrointestinal bleeding, the outcome of the patients were significantly improved with a restrictive transfusion strategy in which the hemoglobin threshold was 7 g/dl as compared with a liberal transfusion strategy in which the hemoglobin threshold was 9 g/dl [25] **1b**.

In patients aged ≥50 years undergoing cardiac surgery to repair heart failure and history of cardiovascular disease with postoperative hemoglobin concentrations lower than 10 g/dl; liberal blood transfusion did not affect 3-year mortality compared with a restrictive transfusion strategy in heart failure patients with cardiovascular diseases [26] 1b.

A restrictive transfusion threshold after cardiac surgery was not superior to a liberal threshold with respect to morbidity in patients older than 16 years undergoing non-emergency cardiac surgery. During the entire admission, 63.7% of the patients in the restrictive threshold group and 94.9% of those in the liberal threshold group received transfusions. Post-operative cardiovascular complications, infections and duration of stay in hospital were the same in both study arms [27] **1b**.

Transfusion requirements in surgical oncology patients is studied by De Almaida et al. and the results showed that liberal transfusion strategy with a hemoglobin trigger of 9 g/dl is associated with fewer major postoperative complications in patients having major cancer surgery compared with a restrictive strategy [20]**1b**.

A randomized clinical trial done by Korch et al. identified that the red blood cell transfusion triggers in cardiac surgery allocated patients to a transfusion hematocrit trigger of 24% versus 28% to compare morbidity, mortality and resource use. Nonetheless, postoperative complications and lengths of stay were similar in the two groups suggesting balanced risk. Finally the author recommended that lower transfusion threshold because, it supports blood conservation efforts without increasing adverse events [23] **1b**.

According to the National Blood Authority guideline, red blood cell transfusion should not be dictated by hemoglobin concentration alone but, should also be based on assessment of the patient's clinical status. Where indicated, transfusion of a single unit of RBC followed by clinical reassessment to determine the need for further transfusion is appropriate. This guideline strongly recommendeds to transfuse RBC when Hb concentration <7 g/dl [28]**1a**.

For patients with acute coronary syndrome with Hb concentration <8 g/dl, the red blood cell transfusion may be associated with reduced mortality and is likely to be appropriate. However, the effect of RBC transfusion on mortality is uncertain with hemoglobin concentration of 8–10 g/dl and may be associated with an increased risk of recurrence of myocardial ischemia [23,27] **1a**.

The European Society of Anesthesiologists recommended that the target hemoglobin concentration should be 7–9 g/dl during active bleeding. Continuous hemoglobin monitoring can be used as a trend monitor and a restrictive transfusion strategy which is beneficial in reducing exposure to allogenic blood products [29]**1a**.

The American Society of Anesthesiologists recommended the restrictive red blood cell transfusion strategy to reduce transfusion administration. The determination of whether hemoglobin concentrations between 6 and 10 g/dl justify or require red blood cell transfusion should be based on potential or actual ongoing bleeding, intravascular volume status, signs of organ ischemia and adequacy of cardiopulmonary reserve [30]**1a**.

The recent National Institute for Health and Care Excellence (NICE) blood transfusion guideline recommended using restrictive transfusion thresholds for patients who need red blood cell transfusions and are not having a major hemorrhage. Consideration of single unit transfusion is also recommended. These strategies are applicable to the stable anemic postoperative patient but not for the intraoperative active major hemorrhage. The NICE guideline recommended to use restrictive red blood cell transfusion thresholds for patients who need red blood cell transfusions and who do not have major hemorrhage or acute coronary syndrome and those who require regular blood transfusions for chronic anemia [31]**1a.**

The American Association of Blood Banks (AABB) recommended Hb 7–8 g/dl as the target in stable patients without coronary artery disease. The AABB recommended that hospitalized patients with pre-existing cardiovascular disease should be transfused for Hb ≤ 8 g/dl or for anemic symptoms [32] **1a.**

3.3. *Risks of allogenic blood transfusion*

The risk of transmission of infectious diseases has reduced significantly in recent years through improved manufacturing and laboratory processes. Nevertheless, there is still a small potential for transfusion of an unrecognized infectious agent. Despite improvements in systems management, there remains a risk of transfusion related harm due to administrative error. Such an error has the potential to result in acute hemolytic reaction from ABO incompatibility, which may be fatal [19]**1b.**

3.4. *Predictors of allogenic blood transfusion*

Cohort studies of predictors of allogenic blood transfusion after shoulder arthroplasty by Ponce et al. shows that allogenic blood transfusion during shoulder arthroplasty had a significantly higher

Table 2
List of recent transfusion articles on guidelines.

Guidelines				
SN	Society, year of publication	Red blood cell transfusion threshold	Clinical setting	References
1	National Blood Authority, 2013	Hb level <8 g/dl	In the absence of acute myocardial or cerebrovascular ischemia, postoperative transfusion may be inappropriate for patients with Hb level >8 g/dl.	[40]
		Hb level <8 g/dl	Patients with acute coronary syndrome	
2	European Society of Anesthesiology, 2017	Maintain Hb 7–9 g/dl	Active bleeding	[41]
3	American Society of Anesthesiologists, 2015	Hb level <6 g/dl	Perioperative blood management	[39]
4	The National Institute for Health and Care Excellence blood transfusion guideline, 2015	Hb level ≤8 g/dl	(Target: Hb 8–10 g/dl after transfusion) for patients with acute coronary syndrome. Individual thresholds and Hb concentration targets for each patient who needs regular blood transfusions for chronic anemia.	[38]
5	American Association of Blood Banks, 2016	Hb level <7 g/dl	Hospitalized adult patients who are hemodynamically stable, including critically ill patients	[32]
		Hb level <8 g/dl	Patients undergoing orthopedic surgery or cardiac surgery and patients with preexisting cardiovascular disease	

Table 3
Meta-analysis and Systematic review.

Meta-analysis and Systematic Review					
SN	Author, year	Number of RCT/Patients	Target population	Results (Restrictive Transfusion Threshold Vs Liberal Transfusion Threshold)	Ref.
1	Salpeter, 2014	3/2,3641	Critically ill patients	Significant reduction in cardiac events.	[21]
2	Curley, 2014	6/1,262	Patients undergoing cardiovascular surgery	No significant differences in terms of adverse event rates (mortality, myocardial infarction, stroke, acute renal failure, infections, duration of stay).	[42]
3	Brunskill, 2015	6/2,272	Patients undergoing hip fracture surgery	No differences in mortality functional recovery, and post-operative morbidity.	[43]
4	Holst, 2015	31/9,813	Surgical and medical patients	No significant differences in terms of overall morbidity and mortality risks.	[15]
5	Fominisky, 2015	27/11,021	Perioperative and critically ill adult patients	Liberal transfusion strategy compared with restrictive strategy improved survival in peri-operative patients.	[22]
6	Ripolles, 2016	6/2,156	Critically ill patients/patients with acute coronary syndrome	No significant differences in terms of mortality.	[19]
7	Carson, 2016	31/12,587	Hospitalized adult patients	No significant differences in terms of mortality.	[1]
8	Hovaguimian, 2016	31/14252	Patients with cardiovascular disease undergoing cardiac or vascular procedures or orthopedic	Restrictive strategies seemed to increase the risk of events reflecting inadequate oxygen supply.	[24]
9	Docherty, 2016	11/3033	patients with cardiovascular disease	The risk of acute coronary syndrome in patients managed with restrictive compared with liberal transfusion was increased.	[36]

Table 4
Randomized controlled trial.

RCT						
SN	Author/Year	Study	Population/Patient Number	Transfusion threshold	Results	Ref.
1	Villanueva C et al.	Patients with history of upper GIT bleeding	Patients with severe acute upper gastrointestinal bleeding/921	Restrictive (Hb < 7 g/dl) (target: Hb 8.0 and 10 g/dl). Vs Liberal (Hb < 9 g/dl) (Target: Hb 9.0 −11.0 g/dl).	Restrictive transfusion strategy was associated with improved outcomes in patients with acute upper gastrointestinal bleeding.	[44]
2	Carson,2015	Functional outcomes in cardiovascular patients undergoing surgical hip fracture repair	Patients aged ≥50 years undergoing surgery to repair a heart failure and history of cardio vascular disease or risk factor for cardiovascular disease	Restrictive (Hb < 8 g/dL) Vs Liberal (Hb < 10 g/dl)	Liberal blood transfusion did not affect 3-year mortality compared with a restrictive transfusion strategy in heart failure patients with cardiovascular disease.	[26]
3	Murphy,2015	Transfusion indication threshold reduction	Patients older than 16 years undergoing non-emergency cardiac surgery	Restrictive (Hb < 7.5 g/dl) VS Liberal (Hb < 9 g/dl)	A restrictive transfusion threshold after cardiac surgery was not superior to a liberal threshold with respect to morbidity.	[37]
4	De almeida,2015	Transfusion requirements in surgical oncology patients	Patients undergoing major cancer surgery admitted to intensive care unit	Restrictive (Hb < 7 g/dl) VS Liberal (Hb < 9 g/dl)	Liberal transfusion threshold transfusion therapy is more effective than restrictive transfusion threshold	[20]

predictive value with patient medical co morbidities [33] **2a.**

The factors determining risk of allogenic transfusion are low preoperative hemoglobin or hematocrit, either before intervention or on day of surgery, low weight, female sex, age over 70 years, estimated surgical blood loss, coagulopathy, type of surgery, primary or revision surgery [17,33–35] **2a,1b,2a,1b.**

3.5. Area of controversies

The recent clinical trials in adults have provided level I evidence to support restrictive red blood cell transfusion practices. However, some advocates have attempted to identify "correct" Hb threshold for RBC transfusion whereas others assert that management of anemia including transfusion decisions must be taken into account based on clinical patient variables rather than simply one diagnostic laboratory test. The heterogeneity of guidelines for blood transfusion by a number of medical societies reflects this controversy [14]**1a.**

Data from three randomized controlled trials of critically ill patients showed that a hemoglobin threshold <7 g/dl significantly reduces negative outcomes as well as in-hospital and total mortality when compared to a hemoglobin threshold <8 g/dl. The systematic reviews clearly suggest that a restrictive RBC transfusion strategy is equivalent or superior to a more liberal strategy in morbidity and mortality [21] **1a.**

In contradiction, Fominisky and colleagues, after analysis of RCT with 11,021 patients, concluded that liberal transfusion therapy is superior to restrictive transfusion therapy in terms of overall survival in preoperative adult patients. Restrictive red cell transfusion policies are recommended as safe for most hospital patients with anemia. Uncertainty exists for patients with cardiovascular disease, whose hearts may be more susceptible to limited coronary oxygen supply [36]**1a.**

Guidelines such as the American Society of Anesthesiologists, the American Association of Blood Banks and National Institute for Health and Care Excellence are recommended to use restrictive transfusion strategy [37–39]**1a.** However, several randomized studies in different clinical contexts have recorded an increase in morbidity-mortality among patients assigned to restrictive transfusion criteria [20,22].

3.6. Summary of evidences

The red blood cell transfusion threshold for patients with acute coronary syndrome is determined as (Hb < 8 g/dl).On the other hand, the red blood cell transfusion threshold of patients undergoing orthopedic surgery, cardiac surgery and patients with pre-existing cardiovascular disease is determined as (Hb < 8 g/dl); while in hospitalized adult patients who are hemodynamically stable, including critically ill patient is (<7 g/dl) (Table 2**).**

The liberal transfusion strategy compared with restrictive strategy improves the survival rate in peri-operative critically adult patients. However, Meta-analysis and systemic reviews stated the non-significant differences in restrictive VS liberal transfusion strategy in terms of postoperative morbidity and mortality; in patients undergoing cardiovascular surgery, hip fracture surgery, patients with acute coronary syndrome and hospitalized adult patients (Table 3).

The liberal transfusion threshold is more effective than restrictive transfusion threshold in patients undergoing major cancer surgery admitted to the intensive care unit. However; restrictive transfusion threshold after cardiac surgery is not superior to the liberal transfusion threshold with respect to morbidity in patients older than 16 years undergoing non-emergency cardiac surgery (Table 4).

4. Conclusions and recommendations

Most guidelines and literature stress that blood transfusion should not be only hemoglobin value alone, it should be considered clinical symptom of anemia and predictor of transfusion. The use of only single value of hemoglobin level as a trigger for transfusion should be avoided. Evaluation of the patient's clinical situation should be a factor in the decision for blood transfusion including individual patient's intravascular volume status, evidence of shock,

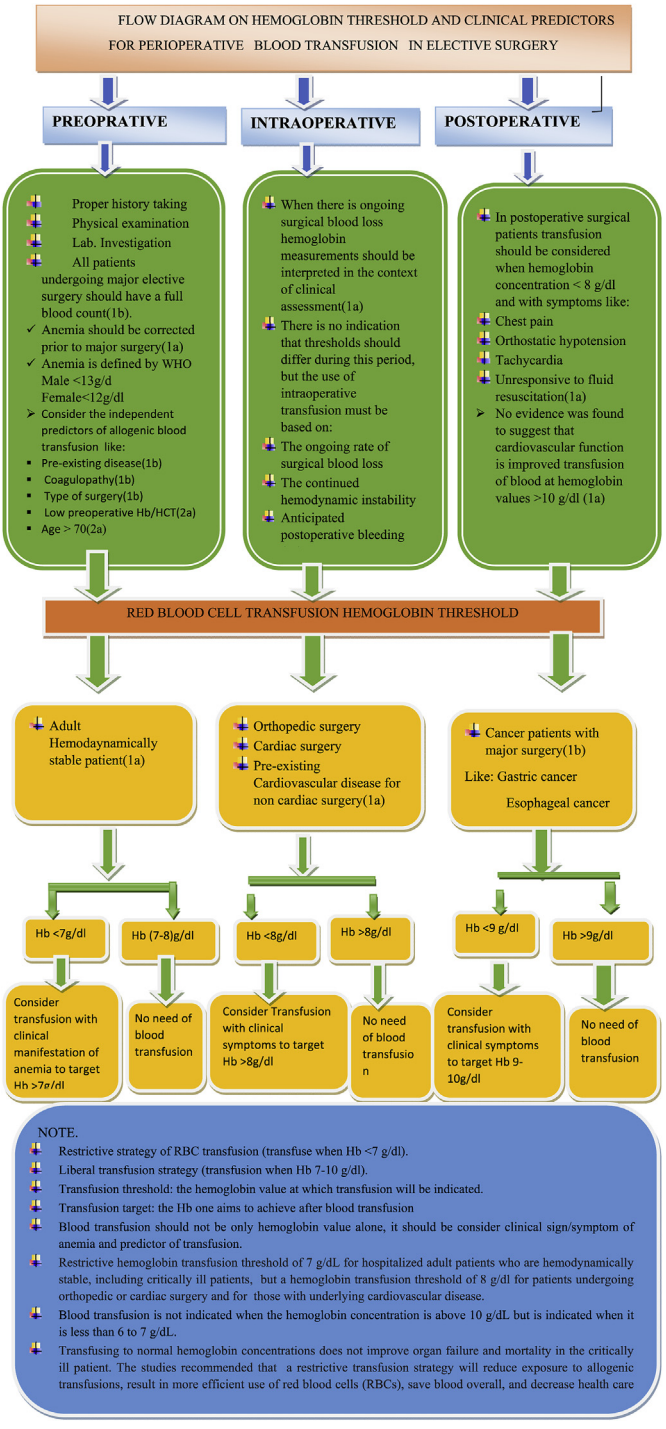

Fig. 2. Flow diagram on hemoglobin threshold and clinical predictors for perioperative blood transfusion in elective surgery..

duration and extent of anemia, cardiopulmonary physiologic parameters and other predictors of transfusion **(2a).**

A restrictive strategy of blood transfusion (transfuse when Hb is < 7 g/dl) is as effective as a liberal transfusion strategy (transfusion when Hb is < 10 g/dl) in critically ill patients with hemodynamically stable anemia except, in patients with acute myocardial infarction or unstable myocardial ischemia **(1a).**

Consider transfusion if Hb is < 8 g/dl in critically ill patients with preexisting cardiovascular disease and acute coronary syndromes. No benefit of a liberal transfusion strategy (transfusion when Hb is < 10 g/dl) in critically ill patients with cardiac disease **(1b**).

In postoperative surgical patients, transfusion should be considered at a hemoglobin concentration of <8 g/dl with symptoms (chest pain, orthostatic hypotension or tachycardia unresponsive to fluid resuscitation **(1a).** High-quality evidence from adequately powered randomized controlled trials with measurement of appropriate patient outcomes is needed in different patient populations so that optimum transfusion triggers can be defined. A lower threshold such as Hb of 6 g/dl blood transfusion is strongly recommended **(1a).**

Overall a flow diagram on hemoglobin threshold and clinical predictors for perioperative blood transfusion in elective surgery **is designed as follow** (Fig. 2**).**

Declarations

Ethical approval

[Not required.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Declaration of competing interest

We the authors did not have any competing financial or personal relationships that could be viewed as influential for the work of this paper.

Acronyms and Abbreviations

AABB	American Association of Blood Bank
AAGBI	Association of Anesthetists of Great Britain and Ireland
G/dl	gram per dice Littre
Hb	Hemoglobin
NICE	National Institute for Health and Care Excellence
PRISMA	Preferred Reporting Item for Systematic Review and Meta-Analysis
RBC	Red Blood Cell
RCT	Randomize Control Trial

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tacc.2019.12.003.

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