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Blood transfusion practices in the operating room

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Abstract

Introduction: Blood transfusion is a therapeutic procedure frequently performed in the operating room.

Objective: The aim of the study was to analyze transfusion practices in surgery performed in the operating theatre of the Med V military hospital in Rabat.

Patients and methods: This was a prospective descriptive study carried out in the central operating room. All patients transfused during scheduled surgery were included. Patients transfused in an emergency were excluded. The following parameters were recorded for each patient: age, sex, type of operation, transfusion history, ASA class, previous medications interfering with hemostasis or coagulation, type of anesthesia, transfusion criteria, products transfused and patient outcome.

Results: From January 2023 to January 2024, 6362 patients underwent surgery and 306 (4.8%) were transfused. Orthopedic surgery, neurosurgery and urological surgery were the most frequent transfusion recipients. Red blood cells were the most frequently transfused labile blood product (LBBP). The presence of antiplatelet agents, anemia and NSAIDs were predictive of intraoperative bleeding. Indications for transfusion were based on clinical criteria in 84% of cases. 12 patients presented hemorrhagic shock and 18 cases of massive transfusion were noted. The mortality rate was 0.65%.

Conclusion: Transfusion practices remain variable. Management requires detection of bleeding-risk situations. Rationalizing the use of PSL requires the development of protocols.

Keywords: Surgery; Anesthesia; Blood transfusion; Operating room

1. Introduction

Blood transfusion (BT) involves administering blood or its components from a healthy donor to a sick recipient. It aims to compensate for blood loss by ensuring oxygen transport, maintaining blood volume and correcting bleeding. It is commonly practiced in intensive care units and operating theatres, where around a third of patients receive a transfusion during their stay[2]. In the perioperative period, patients are often faced with acute anemia, and the French National Authority for Health (HAS) has set transfusion thresholds based on hemoglobin to ensure sufficient oxygen transport to tissues [3]. However, blood transfusion carries risks of acute or delayed complications, as well as transmission of infections. Although there are numerous recommendations for good practice, transfusion practices vary considerably in surgery, due to the absence of a single transfusion threshold, and the need to consider the type of pathology and co-morbidities of each patient. This context leaves room for improvement. The aim of our study was to analyze transfusion practices in our context and compare them with the recommendations of learned societies.

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2. Materials and methods

The study was a prospective descriptive study conducted in the central operating room of the Med V military hospital in Rabat, over a 12-month period from January 2023 to January 2024. Inclusion criteria concerned patients scheduled for programmed surgery in various specialties (orthopedics, neurosurgery, urology, gynecology, visceral, maxillofacial, ENT, thoracic and ophthalmology). Patients undergoing emergency surgery and those in septic operating theatres were excluded.

Data collected included age, sex, type of procedure, transfusion history, ASA class, drugs interfering with coagulation, blood crase count, type of anesthesia, amount of intraoperative bleeding, transfusion criteria, products transfused and patient outcome (transfer to intensive care or return to the original department).

The decision to transfuse was based on clinical criteria (poor bleeding tolerance) or biological criteria (hemoglobin measured by Hemo cue). The type of product transfused depended on the biological work-up or the evolution of the bleeding. A massive transfusion was defined as a transfusion greater than once the patient's blood mass. Post-operative stay was determined by the type of operation, the extent of bleeding and the patient's characteristics.

Statistical analyses of the data were carried out by expressing quantitative variables as mean ± standard deviation, compared by Student's t-test, while qualitative variables were expressed as percentages and compared by chi-square test. A $p<0.05$ value was considered significant.

3. Results

During the study period, a total of 6362 patients underwent surgery. Of these patients, 59.38% were men and 40.59% were women. The mean age of patients was 54 ± 11 years. The mean age of transfused patients was 65 years.

Surgeries were divided into different specialties: 14.8% of patients underwent trauma surgery, 18.04% digestive surgery, 20.46% ophthalmology, 7.76% stomatology, 12.3% urology, 8.4% ENT, 6.02% neurosurgery, 2.5% thoracic surgery, and 9.47% gynecology.

With regard to transfusions, of the 6362 patients operated on, 306 were transfused, representing an incidence of 4.8%. Of the patients transfused, 185 were male (60.45%) and 121 female (39.55%), giving a sex ratio of 1.52. Blood transfusion was indicated on the basis of clinical criteria of poor bleeding tolerance and/or biological criteria (hemoglobin measured by Hemocue). Of the 306 patients transfused, 49 patients were transfused on the basis of biological criteria, i.e. 16% of the population, while 257 patients were transfused on the basis of clinical criteria (amount of bleeding, clinical impact, etc.), i.e. 84% of the population.

The number of patients who underwent massive transfusion (defined as a transfusion greater than one times the patient's blood mass) was 18. In addition, 12 patients experienced hemorrhagic shock during surgery. Of these, 11 were admitted to intensive care, a rate of 3.5%. Two patients died as a result of hemorrhagic shock, representing a mortality rate of 0.65%.

Table 1 Number of packed red blood cells, PFC, and PQ transfused

Services	CG	PQ	PFC
Traumatology	223	20	24
Neurosurgery	70	12	12
Ophthalmology	0	0	0
Stomatology	8	0	0
Urology	69	18	12
ENT	6	0	0
Digestive	38	40	36
Thoracic	24	10	12

Gynecology	32	20	20
total	470	120	116

GC: red blood cells, FFP: fresh frozen plasma, PQ: platelets

Table 2 Characteristics of patients operated on

Parameters	**Total population (n=6362)**	**Transfused patients (n=306)**	**Non-transfused patients (n=6056)**	**P**
Average age (years) (m ± Et)	54 ± 11	56 ± 9	53 ± 14	0.45
Sex (M/F) (n)	3818 / 2544	185 / 121	4212 / 2744	0.39
ASA (I/II/III/IV) (n)	3359 / 2902 / 91 / 10	137 / 151 / 12 / 6	3462 / 2499 / 74 / 21	0.56
Taking PAAs (yes/no)	1489 / 4873	131 / 175	1671 / 4385	0.024
NSAID use (yes/no)	1152 / 5210	97 / 209	987 / 5069	0.018
Anemia (yes/no)	1163 / 5199	124 / 182	997 / 5059	0.041
Antifibrinolytics (yes/no)	329 / 6033	91 / 215	289 / 5767	0.71
Anaesthetic technique (AG/ALR/ALR+AG)	3587 / 2118 / 657	151 / 121 / 34	3182 / 2479 / 395	0.65
Surgery time (min)	150 ± 34	187 ± 41	167 ± 35	0.68

Table 3 Distribution of patients by surgical specialty

Parameters	**Total population (n=6362)**	**Transfused patients (n=306)**	**Non- transfused patients (n=6056)**
Traumatology	942	96	846
Neurosurgery	385	33	352
ENT	538	4	534
Chir. Thoracic	164	9	155
Chir. Digestive	1148	121	1027
Gynecology	603	11	592
Urology	786	26	760
Stomatology	494	6	488
Ophthalmology	1302	0	1302

4. Discussion

4.1. Estimation of surgical bleeding

During surgery, the patient is exposed to a risk of bleeding, which must be assessed preoperatively to take into account both the risk associated with the surgery itself and that associated with the patient. Surgical procedures at risk of bleeding and patient-specific clinical factors increasing the risk of bleeding must be identified. This enables appropriate measures to be put in place, such as the availability of blood grouping and RAI documents, venous access, and the preparation of transfusion products and materials. In short, bleeding prevention begins even before the patient enters the operating theatre.

4.1.1. Situations at risk of bleeding

The risk of bleeding can be attributed to the surgical procedure or to patient-specific factors.

Procedural factors

According to the HAS Checklist 2011, bleeding becomes significant when it exceeds 500 ml or 7 ml/kg in children. Permissible blood loss is calculated according to the formula: Permissible blood loss (in ml of red blood cells) = VST x (Initial Ht - Threshold Ht), where VST represents total blood volume (70 ml/kg for a man, 65 ml/kg for a woman), Initial Ht is the patient's initial hematocrit, and Threshold Ht is the minimum tolerated hematocrit. Certain surgical procedures, such as cardiac, orthopedic and obstetric surgery, carry a high risk of bleeding. Intraoperative blood loss volumes vary considerably in the literature, ranging from 123 to 1172 ml for prosthetic hip surgery, 100 to 3631 ml for spinal surgery, 155 to 3200 ml for cardiovascular surgery, and 125 to 1500 ml for obstetric surgery. In our study, orthopedic surgery was one of the most hemorrhagic, followed by neurosurgery, urology and digestive surgery.

The study by Franco Verlicchi et al. showed that the probability of receiving a transfusion varied according to gender (49% for men, 60% for women), age and surgical procedure. The probability was 70% for femoral fracture surgery or hip prosthesis revisions, and 50% for total hip replacement surgery, and around 60% for coronary bypass surgery [4]. In our study, however, neither age nor gender were predictive factors of intraoperative bleeding.

Patient-related factors

Patient-specific factors such as acquired or congenital hemostasis disorders can increase the risk of bleeding, especially when antithrombotic drugs are taken. Surgical and invasive procedures present a higher risk of bleeding in patients on anticoagulants. Some studies recommend stopping vitamin K antagonists 5 days before a procedure, while for patients requiring a dental procedure, it is suggested to continue VKA with an oral prosthetic agent or to stop VKA 2-3 days before the procedure, rather than using alternative strategies [6]. Moderate or severe thrombocytopenia also increases the risk of bleeding during invasive procedures. Data on the perioperative management of patients with thrombocytopenia are limited and do not cover all situations encountered in routine practice [7]. In general, the risk of bleeding remains low for thrombocytopenia between 50 and 100 G/l, but becomes greater when the platelet count is below 50 G/l, or if it is associated with other coagulation disorders.

In our study, patients on PAAs showed a higher incidence of bleeding than those not treated with PAAs, this difference being statistically significant (P=0.024). Similarly, there were more patients on NSAIDs in the transfused group than in the non-transfused group, this difference also being significant (P=0.018).

4.1.2. Preventing perioperative bleeding

Preventing perioperative bleeding is based on a therapeutic strategy aimed at correcting pre-existing risk factors linked to the patient and surgical technique, in order to prevent the onset of coagulopathy.

Correcting risk factors:

To prevent bleeding, it is essential to detect any congenital or acquired anomalies that increase the risk of bleeding, to correct hemostasis disorders if necessary, and to manage anti-thrombotic treatments appropriately.

Detection of a hemostasis anomaly at risk of bleeding:

A study by Eckman MH et al. showed that routine tests (PT, APTT, platelets) are not beneficial for assessing bleeding risk in non-surgical or surgical patients without synthetic liver dysfunction or a history of oral anticoagulant use. Furthermore, testing after a first episode of venous thromboembolism is generally not recommended [8].

The French Society for Anesthesia and Intensive Care has published recommendations for the prescription of routine preoperative tests prior to any procedure requiring anesthesia. The aim is to avoid perioperative bleeding complications by appropriately managing hemostatic disorders, whether congenital or acquired. Bleeding risk assessment should include a detailed interview with the patient to look for a personal or family history of bleeding diathesis, as well as a physical examination for signs of coagulopathy. Patients with no history of bleeding diathesis and no conditions disrupting hemostasis should not undergo routine preoperative hemostasis testing [9].

Correction of hemostasis disorders at risk of bleeding

When a patient presents with thrombocytopenia, it is important to assess the bleeding risk according to the type of procedure planned. Moderate or severe thrombocytopenia increases the risk of bleeding during invasive procedures, and prophylactic platelet transfusion may be necessary [10].

Furthermore, prophylactic administration of plasma prior to the onset of bleeding, in a patient with moderately altered coagulation factor concentrations, is not indicated. In the case of chronic hepatocellular insufficiency, correction of the prothrombin time (PT) may be warranted prior to a bleeding-risk procedure [11].

Managing anti-thrombotic treatments:

The management of perioperative antithrombotic therapies is based on the assessment of thromboembolism and bleeding risks. Strategies aim to simplify patient management while minimizing adverse clinical outcomes [6].

Correction of preoperative anemia

Detecting and correcting preoperative anemia prior to a bleeding-risk procedure does not directly alter the risk of bleeding, but it does increase hemoglobin levels, thereby reducing the need for blood transfusion [12].

In our study, the incidence of anemia was higher in the transfused group than in the non-transfused group, with a statistically significant difference (P=0.041).

Preventing the onset of coagulopathy

The onset of coagulopathy in severe hemorrhage is often progressive. At the onset of hemorrhage, hemostasis may remain normal. However, several factors contribute to the onset and worsening of hemostasis disorders during hemorrhage.

One study showed that mild hypothermia (<1°C) can significantly increase blood loss by around 16% (ranging from 4 to 26%), and increase the relative risk of transfusion by around 22% (ranging from 3 to 37%). Maintaining normothermia during the operative period reduces blood loss and the need for transfusion in clinically significant quantities [13].

Severe acidosis (pH < 7.1) also inhibits thrombin generation, leading to platelet dysfunction and accelerated fibrinogen degradation. Although correction of acidosis does not immediately restore induced hemostasis disorders, it does help to improve the patient's condition.

4.2. Effects of anemia on the body

4.2.1. Effects of anemia on the body

Acute anemia may reduce arterial oxygen transport (TaO2) due to decreased hemoglobin ([Hb]), a possible reduction in cardiac output (due to uncompensated volume loss or hypoxic myocardial injury) and lower oxygen saturation (SaO2) through impaired ventilatory function and gas exchange [14, 15].

4.2.2. The adaptive response and compensatory mechanisms of anemia

The aim of compensatory mechanisms in anemia is to maintain adequate oxygenation to meet tissue requirements [16]. Arterial oxygen transport (TaO2) depends on cardiac output (COD), hemoglobin (Hb), oxygen saturation (SaO2) and, to a negligible extent, oxygen partial pressure. The formula for calculating TaO2 is :

$$TaO2 = DC \times CaO2$$

where CaO2 (arterial oxygen content) is defined by the formula:

$$CaO2 = (SaO2 \times Hb \times 1.39) + (0.003 \times PaO2).$$

Dissolved oxygen (0.003 × PaO2) represents only 1.4% of the oxygen combined with hemoglobin [17- 19].

In anemia, microvascular and macrovascular compensatory mechanisms are activated to maintain sufficient oxygen supply, redistributing reduced TaO2 to the most metabolically dependent organs or the most active regions. Tissue oxygen extraction (EO2) is also increased [18, 20].

By increasing EO2, tissue oxygen consumption (VO2) remains constant, up to a certain threshold known as "critical TaO2". Beyond this threshold, the increase in EO2 becomes insufficient, and the cell switches to anaerobic metabolism to ensure minimal ATP production, resulting in the formation of lactate and protons [17, 19, 21, 22].

Critical TaO2 depends on the body's oxygen requirements, and in resuscitation it can be lowered by sedation and hypothermia, while it is increased by fever, agitation and polypnea [21].

4.3. Effects of blood transfusion

4.3.1. Effects of transfusion on TaO2 and VO2

TaO2 depends on cardiac output and hemoglobin level, according to the following formula:

$$TaO2 = Qc \times [Hb] \times SaO2 \times 1.39.$$

However, blood transfusions do not always significantly increase oxygen transport. Increasing the number of red blood cells can actually increase blood viscosity, which can reduce cardiac output and, consequently, oxygen transport. A moderate decrease in hematocrit may even have beneficial effects on microcirculation and oxygen extraction capacity.

Blood transfusions only increase oxygen consumption in situations where VO2 = xTaO2 (as in circulatory shock or severe anemia) [23, 24].

Clinical trials have attempted to determine optimal levels of oxygen intake in resuscitated or high-risk perioperative patients. A meta-analysis of these studies suggests that increasing oxygen intake in the perioperative period is beneficial [25].

In addition, 13 trials evaluated the impact of erythrocyte transfusion on the kinetics of oxygen uptake. Although oxygen uptake increased uniformly, only five studies observed a change in oxygen consumption [23].

4.3.2. Benefits of blood transfusion:

Restrictive transfusion (Hb < 7 g/dl) is more beneficial than liberal transfusion (Hb < 10 g/dl) in intensive care, with a reduction in mortality [26-28]. Furthermore, a perioperative study showed that transfusion at [Hb] > 8 g/dl increased postoperative mortality [29].

4.4. Blood transfusion products

4.4.1. Labile blood products (PSL)

- Red blood cell concentrates (RBCs): treat anemia and can be stored for 42 days. They can be phenotyped or irradiated as required [30].
- Platelet concentrates (PCs): treat thrombocytopenia, can be stored for 5 days [30].
- Therapeutic plasma (PFC): To correct coagulation disorders, stored frozen for one year [30].

4.4.2. Stable blood products

- Albumin: Maintains oncotic pressure and blood volume.
- Immunoglobulins: For immune deficiencies.
- Coagulation factors: Used in the treatment of hemophilia and coagulation factor deficiency [30-34].

4.5. Complications of blood transfusion

Transfusion complications are linked to a number of factors: product quality, genetic diversity, recipient pathologies, human error and organizational shortcomings. Although progress has been made in improving product quality and limiting infectious risks, new threats and non-infectious complications continue to exist, making assessment of the benefit/risk ratio crucial before any transfusion.

4.5.1. Product risks

Transmission of major viruses

The risk of transmission of viruses such as HIV, HCV and HBV has been greatly reduced in recent decades, with a current risk of 1 in 1,250,000 donations [49, 50].

Bacterial contamination

The risk of bacterial contamination is now higher than that of viruses, with a rate of 1 in 167,500 transfusions in France. This contamination may be due to donor bacteremia or inadequate disinfection [51, 52].

New infectious threats

Agents such as CMV, EBV, HTLV-1, West Nile virus, and parasites such as malaria can theoretically be transmitted by transfusion. The risk of transmission of prions, such as Creutzfeldt-Jakob disease, remains low, although it is possible. Donor selection, leukoreduction and screening are preventive measures [49, 53].

4.5.2. Risks associated with the recipient's clinical profile

Non-hemolytic febrile reaction

This is the most common transfusion reaction and is generally benign. It may be caused by cellular activation products or complement fractions [49].

Allergic risk

These reactions account for 26% of transfusion-related incidents and can range from pruritus to anaphylactic shock, due to degranulation of mast cells activated by substances contained in transfused products [49].

Acute pulmonary oedema (APO)

Cardiogenic PAO often occurs after too rapid a transfusion in a patient with cardiac or renal insufficiency. It should be distinguished from TRALI (transfusion-related acute lung injury), a lesional pulmonary edema associated with an immunological reaction between donor and recipient [54-57].

Transfusion-related graft-versus-host disease (GVH-PT)

GVH-PT is now rare thanks to leukodepletion and irradiation of packed red blood cells, especially in immunocompromised patients [49, 57].

Incompatibility in the HLA system

HLA incompatibility can lead to reactions such as RFNH, TRALI or GVH-PT, and requires testing of the recipient's serum for anti-HLA antibodies. The use of leukodepleted and irradiated blood, together with premedication, can prevent these reactions [49, 58].

4.5.3. Risks related to the organization of care

Organizational errors can lead to ABO, Rh or other incompatibilities, resulting in acute intravascular hemolysis. The risk of such incidents is estimated at 1 in 150,000 transfusions, with rigorous checks at the patient's bedside now mandatory [59, 60].

4.5.4. Blood transfusion-related immunodepression

Exposure to foreign erythrocytes can lead to allo-sensitization and immunosuppression, favoring postoperative infections, reactivation of latent viruses and recurrence of cancers. However, there is no strong evidence that transfusion significantly increases these risks, although there are presumptions [60-63].

4.6. Massive transfusion

Mass transfusion is defined as the rapid administration of a large quantity of blood, i.e. more than 5 liters, at least 10 packed red blood cells (PRBCs), or the equivalent of a blood mass in less than 24 hours, or a very rapid transfusion of up to 100 ml/min. There are several risks involved:

- Platelet changes,
- Dilution of coagulation factors,
- Disseminated intravascular coagulation (DIC),
- Hypothermia,
- Metabolic disorders (hypocalcemia, hypokalemia),

- Hemostasis disorders and massive hemorrhage [64-66].

4.6.1. Hypothermia

RGCs are stored between 2 and 8°C. Massive transfusion can lead to hypothermia, particularly in children. It may also lead to more frequent cardiac arrhythmias [64-66].

4.6.2. Hemostatic abnormalities

Massive transfusion can cause clinically significant haemostatic abnormalities. Dilution of coagulation proteins and platelets in the blood can reduce the concentration of coagulation factors by 25%.

Thrombocytopenia occurs in 33% of cases (platelets < 50,000 /dl), and DIC in 5-20%. In one case series, 18 massive transfusions required the use of labile blood products.

4.6.3. Metabolic disorders

Metabolic disorders, notably hypocalcemia and hypokalemia, are mainly related to citrate, the anticoagulant used in whole blood bags. Acidosis and hypocalcemia are more frequent with massive plasma transfusions.

Prognosis

In our study, 12 hemorrhagic shocks were observed, with 11 patients requiring a stay in intensive care, and a favorable outcome in 9 cases. The mortality rate was 0.65%.

5. Conclusion

Blood transfusion (BT) is a therapeutic procedure commonly performed in operating theatres. Given the shortage of labile blood products and the inevitable risks associated with transfusion, appropriate use of blood products is essential. This use must be guided by the specific indications of each product, its side effects, the thresholds tolerated in surgery, and local transfusion protocols.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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