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Review

Perioperative Blood Management: Pros and Cons of ANH and Cell Salvage

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Increasingly, autologous blood transfusion has been arousing concern owing to awareness of adverse effects of allogenic blood transfusion, blood shortage and patients, having religious or personal issues. With the development of medicine, Cell Salvage and Acute normovolemic hemodilution (ANH) has been proposed as an alternative to allogenic blood transfusion. This review looked at the use of ANH and cell salvage and evaluated the benefits and usefulness based on the strengths and indications. Although not consistent with all cases of ANH, there were benefits in the amount of hemorrhage and transfusion, and no supplementary plasma or platelet transfusion was needed after surgery when employing ANH. But, it showed a cutoff value only for massive bleeding surgery (at least 500 mL). In the case of cell salvage, the amount of blood transfusion was reduced in most cases and platelet or plasma transfusion was not required in most cases. When the Leukoreduction filter (LDF) was utilized, it showed the effect of removing bacterial infection or tumor cells. Nonetheless, the effectiveness and benefits for patients in certain condition of cell salvage and ANH is ambiguous with discrepancies among studies or patients. Therefore, the aim of this study is to provide clinical knowledge relative to the procedure, measure the efficacy and usefulness of peri-operative blood management mentioned above and discuss the forthcoming prospects and challenges.

Key words: Blood transfusion; Autologous; Operative blood salvage; Hemodilution

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INTRODUCTION

Without doubt, allogenic blood transfusion has been an important lifesaving option in some circumstances. However, allogenic blood transfusion also has its drawbacks. Side effects of allogenic blood transfusion, blood scarcity and individual religion problem like Jehovah's witnesses are major issues [1,2]. In this respect, there has been much effort to replace allogenic blood transfusion such as using pharmacological agent, injecting topical vasoconstrictive agent, induced hypotension, intravenous iron, erythropoietin, coagulant and so on [3]. In addition, with growing technology, Cell salvage and Acute normovolemic hemodilution (ANH) has emerged as a substitute for allogenic blood transfusion [3,4]. First, Cell salvage became widely known in the late 1970s due to the infection threat like viral hepatitis and HIV infection from allogenic blood transfusion [5]. Namely, it was introduced in an optimal time to the world. Even now, cell salvage is a useful and effective technique with a low risk of transfusion-borne infection. Second, ANH has been utilized and its efficacy studied since the 1960s [6,7]. ANH is also considered to be helpful in cutting back the volume of allogenic blood transfusion and transfusion of autologous whole blood [8]. Nonetheless, still the efficacy and utility of ANH and cell salvage is unclear with pros and cons due to inconsistent conditions among various articles and outcome from journals ranging from effectiveness to insignificance or being unthrifty when considering other facilities. Hence, through this study, we provide clinical information about procedures mentioned above, gather various articles about cell salvage and ANH and make a conclusion whether cell salvage and ANH is effective or

not [9].

ACUTE NORMOVOLEMIC HEMODILUTION

1. ANH procedure [6]

The ideal timing to undertake ANH is just after anesthesia commences, but it also could be done when the patient sheds a lot of blood. Before surgery, the patient's whole blood has to be extracted from vessels; using a 20G catheter with arterial pressure as a pump when drained from an artery and 16G or 14G catheter when drained from a vein by gravity. The amount of blood to be extracted can be determined by the formula given in Gross [10]: BV=EBV×2(HctIn–HctTa)/(HctIn+HctTa); HctIn is initial hemoglobin concentration; HctTa is Target hemoglobin concentration; EBV is the expected amount of bleeding, which is the amount of fluid in the body per kilogram (usually 60 to 65 mL/kg for men and 67 to 70 for women) multiplied by body weight. The extracted blood is stirred with a full dose of anticoagulant to prevent clotting and then kept in a freezer near zero degrees. Then to compensate for hemodilution, crystalloid or colloid fluid should be injected. At this point, it is important to note that the solution may disappear into the interstitium soon after [6]. Fig. 1. shows a blood bag filled with autologous blood.

2. Advantage of ANH [6,7,11]

Generally, it is easy to understand that up-to-date and new techniques are expensive. Nevertheless, ANH is a quite reasonable remedy in curtailing the volume of allogenic blood transfusion. The powerful advantage is in the technique itself. Because there is only one way to extract ones' own blood in its entirety, ANH can supply fresh autologous blood where most platelets and clotting factors are preserved and red blood cells (RBCs) are rarely lost. Moreover, when draining ones' own blood, there is no need to examine the transfusion between the blood and the patients and there is no need to worry about transfusion side effects. Finally, because ANH is simpler than any other method, the process is simple, cost effective and can save blood storage time.

Fig. 1. Autologous blood extracted during the perioperative state as shown is contained in the transfusion bag.

3. Indication of ANH [6,12,13]

ANH began with efforts to reduce allogenic blood transfusion by reducing RBC loss from bleeding [8]. For example, if the operation is expected to have a blood loss of 2 L, the RBC loss is twice as low as at 7 when the hematocrit is 14 g/dL. Therefore, it is possible to apply practically if a large amount of bleeding during surgery is expected. Common indications for its use in surgery are listed in the following Table 1.

4. Effectiveness of ANH

As can be seen from Table 2, the amount of blood transfusion in the ANH meta-analysis performed independently of the department was reduced consistently [7,8,13]. In a study by Segal et al. [7], the volume of about 303 mL of RBC transfusion could be saved. There were no more side effects compared to the control group [7,8].

Studies in cardiac surgery have shown that ANH can reduce blood transfusions [14]. In addition, the number and function of platelets (PLTs) are not significantly different before and after surgery [9,15]. This is because theoretically PLT or coagulation factor

Table 1. Indication of ANH in surgery part

Department	Surgical procedure
Cardiac procedure	With or without extracorporeal circulation
Neurosurgery	Tumors Aneurysms
Orthopedics	Scoliosis Prosthetics
Vascular	Aneurysms reconstructive surgery
Thoracic	Pneumonectomy Lobectomy
Urologic	Prostatectomy cystectomy nephrectomy
Others	Rare blood groups patients who have never experienced transfusion

Table 2. Studies included in review article concerning effectiveness of ANH

Authors	Years of publication	Methods	Risk of transfusion	Amount of transfusion	PLT and plasma transfusion	Perioperative blood loss	Adverse effect	Others
Segal. et al. [7]	2004	Meta-analysis	NS	Less in ANH‡		Less in ANH‡	NS	
Bryson et al. [13]	1998	Meta-analysis	Less in ANH	Less in ANH			NS	
Zhou et al. [8]	2015	Meta-analysis		Less in ANH‡			NS	Less infection risk
Cardiac surgery								
Goldberg et al. [16]	2015	2337 cases study			Less in ANH‡	Less in ANH‡	Less in ANH†	Performed in condition of 800 mL or more
Barile et al. [14]	2017	Meta-analysis		Less in ANH‡		Less in ANH‡		
Virmani et al. [9]	2010	Prospective randomized control			NS	Less in ANH*	NS	
Sebastian et al. [15]	2017	Prospective study		Less in ANH‡	Less in ANH‡			
Orthopedics								
Qureshi et al. [46]	2017	68 cases study		Less in ANH*		Less in ANH†		
Neurosurgery								
Oppitz et al. [17]	2013	100 cases prospective study			Less in ANH*			Useful in low grade cerebral aneurysm
General surgery								
Guo et al. [39]	2013	30 cases study		Less in ANH*		NS		PT and aPTT were prolonged before but within normal range

NS, not significant; ANH, acute normovolemic hemodilution; PT, prothrombin time; aPTT, activated partial thromboplastin time. *P<0.05. †P<0.01. ‡P<0.001.

may disappear in the case of cell saver, but ANH does not lose its coagulation materials because it re-injects fresh whole blood to patients. Notably, the use of ANH is more effective in surgery where massive hemorrhage is expected [15,16]. According to the study by Goldberg et al., ANH can be used to maximize the effect of ANH in bleeding over 800 mL [16].

As it was expected in other areas such as neurosurgery, orthopedics and general surgery, additional PLT plasma transfusion was not required and did not result in coagulopathy after surgery. Although not consistent, the overall blood transfusion volume was reduced. Particularly in neurosurgery, the oxygen supply to the brain was better in the ANH group than in the control group [17].

As a result, ANH has shown no consistent results but has positive effects on the volume of RBC transfusion, perioperative blood loss, PLT count, PLT function and loss of coagulation factors. Especially, it is more effective when applied to suspected massive bleeding or bleeding. Although overall ANH is effective, additional research is still needed.

5. Disadvantage of ANH [18]

Hemodynamic repercussion is a problem that can occur when using ANH [18]. For example, coagulation factors and RBCs are lost which can lead to bleeding problems, hypotension and tachycardia during surgery. That is why it is controversial whether it is applicable in patients with coronary artery disease, anemia and clotting disorders. In these patients, careful evaluation of potential problems should be completed before application. In addition, the major problem in ANH is sepsis, which is also contraindicated if there are abnormalities in major organs such as the lungs and kidneys or bacteremia [6].

6. Cell salvage

Cell salvage started with the idea of re-using scattered blood during postpartum hemorrhage in 1818. Since then, similar attempts have been made in various medical parts. However, most trials resulted in a high mortality. In this flow, autologous blood transfusion has lost interest with the appearance of allogenic blood transfusion in the 1940s and 1950s [19]. Even with this trend, self-transfusion methods were considered continuously and were developed, but failed due to various side effects like hemolysis, air embolism and coagulation disorder. Finally, the first available device was introduced into the world was called the 'cell saver'. Today, the cell saver is generally understood as a blood salvage apparatus [5].

Fig. 2. Well-known cell salvage machine: cell saver.

7. How to operate cell salvage [5,19]

The 'cell saver' machine, which is widely used today, is shown in Fig. 2. Recently, self-transfusion machines, so-called cell saver, work in three phases; gathering, cleaning and re-injection. Gathering blood from patients who are in the operating room and bleeding a lot requires a specially designed double lumen catheter. Why do these devices need two lumens? Red blood cells (RBCs) exposed in air need immediate anticoagulant such as heparin or citrate because of coagulation. Thus, apart from the lumen into which the anticoagulant is inserted, another lumen is required to pass the blood from patients to reservoir [19]. Blood mixed with heparin or citrate is collected in a bowl and its composition is separated by centrifugation within it [5]. At this time, appropriate bowl volume and filling rate must be considered. Improper bowl volume causes more white blood cells (WBCs) to remain due to inadequate residue removal, which further destroys the balance of the hematocrit. In addition, if the filling rate is too fast, the RBCs will be lost into the debris reservoir. After collection and component separation, the RBCs are washed with a calculated amount of normal saline. That amount

varies from situation to situation, but in most cases, it is estimated to be three times the volume of the bowl. RBCs that have undergone all the procedures so far are put into a transfusion pack with normal saline and then re-injected to the patient, where the hematocrit is about 50 to 80% [19].

8. Advantage of cell salvage

The advance of cell salvage is that it can reduce allogenic blood transfusion and provide better quality RBCs. Allogenic blood transfusion can cause blood-borne infections such as hepatitis C or HIV. In addition, there are still transfusion errors when transfusing globally and immunological problems are being reported. Cell salvage is valuable in relieving allogenic transfusions, specifically lowering their exposure by 39% and minimizing the average reduction of 0.67 units per person [20].

If the RBCs come out of the body, they will be damaged in any way. Thus, the values that indicate viability of RBCs such as 2,3-DPG and cell membrane variability are very important [19]. First of all, 2, 3 DPG plays a role in releasing oxygen after transporting oxygen. In case of cell salvage, the level of 2,3-DPG is about 5% lower, which is not significantly different from fresh blood. On the other hand, in the case of blood stored for about 25 days, the value is reduced by 90% or more [5]. Secondly, because RBCs are usually larger than the minimum diameter of the capillaries, the flexibility of the RBC is important to allow smooth passage. According to study by Hovav et al. [21], in blood salvaging, deformability maintains biconcave disc shape almost similar to fresh blood, but echinocyte shape is observed in long-term stored blood for allogenic blood. Taken together, the above two facts show that salvaged RBCs are more adapt to carry oxygen.

9. Indication of cell salvage

Cell salvage can be performed in elective surgery or in some emergent surgeries where massive bleeding is suspected. In particular, it is now known to be used in obstetrics, vascular, orthopedics, pediatrics, neurosurgery, cardiac and urologic subdivisions [22]. Although not used in all operations of all branches, specific examples that are mainly applied are listed in Table 3 below.

10. Effectiveness of cell salvage

Let's look at the effect of cell salvage on each part through Table 4. First of all, most articles in cardiac surgery were CABG surgery using cell salvaging. As a result, it has been reported in 4 studies that the cell saver has played an outstanding role in reducing blood transfusion [23-26]. Although disadvantage may be mentioned, it is predicted that the disadvantages of cell salvage may be dilutional coagulopathy, which may lead to a large number of transfusions of platelets or coagulation factors, but there was no difference between the two groups [23-25]. In addition, they have not come to the conclusion that they are useful in terms of cost or whether or not it is useful [26].

Neurosurgery included only one case report, but the case was re-

Table 3. Indication of cell salvage

Department	Surgical procedure	Latest knowledge
Obstetrics		In combination with Leukocyte depletion filter (LDF) have endorsed
Vascular	Abdominal aortic aneurysm (AAA) Aorto-femoral bypass surgery	
Orthopedics	Revision hip Total knee replacement surgery Spine surgery	
Pediatrics	Craniosynostotic correction Cardiac surgery	
Neurosurgery	Intracranial surgery	It can be applied if there is suspicion or possibility of massive bleeding.
Cardiac	Cardiopulmonary bypass (CPB) Primary coronary surgery Isolated valve replacement	
Others	To alleviate the volume of allogenic blood transfusion Patients who reject to transfuse	

Table 4. Studies included in review article concerning effectiveness of cell salvage

Authors	Years of publication	Study method	Amount of transfusion	PLT and plasma transfusion	Perioperative blood loss	Adverse effect	others
Cardiac surgery							
Van den Goor et al. [47]	2007	Prospective study	Less in CS	NS			
Al-Mandhari et al. [23]	2015	Prospective observational cohort study	Less in CS*	NS	NS		
Goel et al. [24]	2007	Prospective randomized trial	Less in CS*	Less in CS*		NS	
Wang et al. [25]	2009	Meta-analysis	Less in CS				
Almeida et al. [26]	2013	Prospective study	Less in CS†				Shorter hospital stay but, not cost-effective
Neurosurgery							
Nusrath et al. [27]	2012	Case report					1,000 mL was lost and 450 mL of the blood loss was re-transfused
Orthopedics							
Gum et al. [48]	2017	Retrospective cohort study	Less in CS‡		Less in CS‡		Shorter operation time and less cost in CS
Kelly et al. [28]	2015	Mixed retrospective-prospective cohort study	NS			NS	Cost effective over 500 mL in CS
Miao et al. [49]	2014	Single center, retrospective study	Less in CS*				
Stone et al. [50]	2017	Meta-analysis	Less in CS		NS	NS	
Akgul et al. [29]	2014	Retrospective study	Less in CS*				
Bilgili et al. [51]	2014	Retrospective comparative study	NS		Less in CS*		Not significantly cost-effective
Dusik et al. [52]	2014	Review article	Less in CS				
Vascular							
Konstantinou et al. [30]	2011	Retrospective study	Less in CS				Saving about $ 980 per case
Urologic							
Gilbert et al. [31]	1995	Prospective single center study	NS				Cost $ 433 more
Oncologic							
Lyon et al. [53]	2015	Retrospective single center study			More in CS‡	NS	Longer operation time
Elmalky et al. [54]	2017	Retrospective controlled study	Less in CS*			NS	Not significant difference in cost
Araujo et al. [44]	2016	Retrospective cohort study				NS	
Kumar et al. [32]	2014	Meta-analysis					Using LDF, blood consumption was decreased and tumor cells were reduced or eliminated
Elias et al. [33]	2001	Retrospective study					LDF can remove a lot of cancer cells and it was possible to eliminate all cancer cells by using about 50 Gy of radiation.

NS, not significant; LDF, leukoreduction filter; CS, cell salvage. *P<0.05. †P<0.01. ‡P<0.001.

transfused in about 450 mL of massive bleeding with an EBL of 40%, even for younger patients, with no additional complications or side effects observed. One notable point is that LDF was used to prevent the movement of infection or tumor cells in head and neck surgery. LDF has been shown to be useful for removing various particles as well as tumor cells in various articles [27].

In the orthopedic department, overall results are inconsistent. All but two of the seven studies report that allogenic blood transfusion has decreased. One of the reports stated that blood transfusion was not helpful was that there was no difference, but it is effective in large volumes of estimated blood loss after dividing into subgroups based on the amount of hemorrhage. This study said that the minimal threshold is 500 mL [28]. In the other study, there were no significant differences between groups in most variables including perioperative transfusion [29]. Costs vary from reduced to more heavily expensive. The reason for this is that the price of blood transfusion varies from country to country and the price of cell salvage machines is also different.

It is known to be used mainly in AAA or AFB in the field of vascular surgery. In a study involving 62 patients, 2.52 units of packed RBCs could be reduced and cost savings of $ 980 per case was seen [30]. Of course, because it is a study conducted in Greece, the fact that it is not costly when considering differences across countries is encouraging the use of cell salvage in various fields. However, the radical prostatectomy performed at the urologic field did not show any advantage and in fact costed $ 433 more [31]. However, still serious side effects are not seen in the cell saver group, and the costs are different for each country and can still be considered as an option.

Finally, the oncologic field is the most noticeable and controversial field of the present indications. Although, theoretically there is possibility of dissemination of cancer cells, all oncologic surgeries did not show any recurrence or death complications in the review articles presented above. Contrary to common sense, LDF showed better results than did not [32,33]. Because of the effect of LDF on tumor cells and lowering the inflammatory response, it can be said that LDF can overweigh the various disadvantages of the cell saver, especially when considering cancer [34]. However, because there is still lack of studies such as RCT, it is difficult to apply it directly to patients.

In addition to studies in six branches, cost-effectiveness of cell salvage is mentioned in several articles. Davies et al. show that alternatives to cell salvage as well as other transfusions are sufficiently effective and cost-effective [35]. In addition, the study of intraoperative cell salvage efficiency in South Africa was also found to be beneficial and economical [34,36]. Because of the lack of equipment such as a cell saver, the cost of the equipment is not a benefit, but it is still reasonable in countries where the amount of transfusions is insufficient and the price per RBC unit is high.

11. Contraindication of cell salvage [5,19,22]

Prior to referring to contraindications, the taboo of cell salvage is divided into absolute and relative contraindications, which may or may not be contraindicated depending upon how the condition is controlled, so no mention of the distinction is made. There are four major cases of blood salvage. First, it is an infection problem. For example, if the amniotic fluid, fat, urine, bowel contents, etc. in the cesarean section are mixed, the extracted blood cannot be used. In addition, bacteria or viruses cannot be used for sepsis in the blood. There is a LDF, antibiotics, etc., which will be mentioned again in the discussion [22]. Second, there is cell lysis. If the RBC is originally easy to be damaged, such as sickle cell anemia, there will also be a lot of smashed RBCs in the cell salvage pool. Third, there is a cancer problem. This is currently contraindicated in the opinion that cancer cells may be present in the blood and, if reintroduced, affects recurrence after surgery. However, active research is currently underway on cell salvage in cancer. Finally, patients using agents that cause coagulation, such as thrombin or fibrin, may have problems with coagulation during migration to the saver reservoir [19].

12. Disadvantage of cell salvage

As can be seen from the indications, the problems that blood salvage can pose is that it can cause clotting problems. Autologous blood transfusions with blood salvage can lead to dilutional coagulopathy because only normal saline is mixed with RBCs, unlike ANH [19]. This is similar to the situation where a large amount of allogenic transfusion is required to give platelets with the appropriate ratio among components. For example, in a traumatic situation with a lot of bleeding, there is also a paper written by Holcomb et al. suggesting a ratio of 1: 1: 1 to compensate for platelet reduction [37].

DISCUSSION

Through the Cell saver and ANH, this review article has examined the global flow of peri-operative blood management. Since blood management is a hot potato around the world, various efforts are being made to reduce blood transfusion from others. In the United States, the amount of blood transfusions used in perioperative situations amounts to 14.5 million units, which exceeds 10 billion $ [15]. However, such a new blood management method is not fully established as an allogenic blood transfusion system, so there

is controversy as to when it can be applied and in what situations it should not be applied. Therefore, it is necessary to discuss the problems and how to solve them.

First, ANH extracts the blood to the target hematocrit in a short time and after the course is completed it puts the fluid back into the patient. Thus, tachycardia, hypotension and myocardial infarction or ischemia may occur as a result of the decrease of the blood cells, which reduces the oxygen supply of the tissue. However, according to Barile et al., if the critical threshold is not exceeded, the reduced RBC viscosity is more effective in delivering oxygen to the tissue during CPB surgery [14,17]. Of the 646 patients who underwent ANH, 9 had myocardial infarction or ischemia, and there were no differences in the number of patients in the control group (634 patients, 10) [8]. Because it provides better supply of collateral or stenotic blood vessels in the myocardium and thus compensates for reduced oxygen delivery capacity [8,14,38]. However, some studies still point to the problem of anemic oxygen supply and there is no study to clarify the relationship, so further research is needed.

Second, coagulopathy occurs during surgery because PLT and coagulation factor are collected in transfusion bags after blood is drawn. In addition, as the hematocrit is removed to keep the target hematocrit, PLT and coagulation factors are also diluted, increasing the risk of intra-operative bleeding. Of course, ANH will only raise the intra-operative complication risk because it is a technique that extracts the entire blood back and puts it back in. In this regard, it is said that a reduction of less than 20% of the initial value does not increase the bleeding tendency during surgery [6,13]. Moreover, according to Sebastian et al. study, there was no statistically significant difference between PLT counts and functions before and after surgery, and even with syringes, there was no significant difference in turbulence and PLT degradation [15]. However, the differences in coagulation parameters, different blood sampling times, and different methods of measurement are still limitations [39].

Third, the expected blood loss has a significant impact on the application of ANH. In many studies, ANH is not effective in surgery where a small amount of bleeding is expected. The main advantage of ANH is that it reduces allogenic blood transfusion, as less bleeding reduces the amount of autologous transfusion and reduces the effect of blood transfusion frugality [15,16]. However, there is a need to study the cost savings of ANH which has been well adjusted for each country, because the costs for the unit of transfusion and preparing the equipment and manpower for each country or region are different.

Cell salvage cannot be adapted when contamination occurs. For example, a contraindication is made in the case of sepsis with bacterial infection and the case of a cesarean section with amniotic rupture. Some studies have shown that infections with high frequency were observed in salvage blood, and in as many as 54% of cases, blood culture was positive even after aseptic surgery [40]. Accordingly, washed cell salvage was used to cleanse collected RBCs to reduce risk of infection [41]. In addition, when LDF was added to the cell salvage, the load of infection was reduced by about 98% to 99%, and even when vancomycin was used, negative results were obtained in all culture results [5,40]. However, it is doubtful whether vancomycin can be used in a situation where the use of antibiotics is currently restricted worldwide. In addition, vancomycin is an antibiotic that can be used in Gram-positive bacteria, but further studies are needed to know how other bacteria can be managed. Finally, it is known that LDF also helps to remove or lessen tumor cells [27,32,33], WBCs [42] and amniotic fluid [43] besides bacterial infection. Further study is needed to quantify the degree of LDF removal [33].

Since this cell salvage is a method of collecting and reusing blood cells from the operation, it has been known that cancer cells cannot be reintroduced because they may be present in the blood. However, there have been no studies showing a clear relationship between salvaged blood and cancer recurrence. According to Araujo TLC et al., liver transplantation with HCC did not show a significant difference in recurrence rate and mortality in patients with salvaging and in those without. Rather, early stage cases showed better results [44]. Also, as mentioned in the previous paragraph, the use of LDF significantly reduced cancer cells, and it was clear that all of the tumor cells could be removed by irradiation of about 50 Gy [33]. Nonetheless, there is still a limit to the extent to which RCT cannot proceed from an ethical point of view because cancer is likely to recur in theory.

Finally, it is a matter of platelets and coagulation factors. Cell salvage literally preserves only the red blood 'cell,' so the aforementioned platelets or clotting factors can be lost [19]. Cell saver group received more plasma and platelets and had a statistically significant difference [45]. In this situation, the use of anticoagulants to prevent coagulopathy cannot be used because of the increased risk of intraoperative bleeding. Therefore, can 'PLT saver' which preserve PLTs by directly collecting blood from the body and treating the anticoagulant be developed?

Concerning the transfusion problem, developed countries are not adequately balanced in demand and supply as they undergo an aging population, and in the developing country, the price is still too expensive to use properly. Thus, based on the results of previous studies, the use of cell salvage or ANH is clinically well worth considering and may be a good solution to the shortage of blood trans-

fused in the future. However, several factors hamper the progress of the study and application of perioperative blood management (PBM). First, there is no clear guideline concerning PBM because the exact effect is not known. Second, it is difficult to make a comparison between studies because there are differences in enforcement method and scope of application for each hospital. Finally, each country has different conditions. For example, the introduction of such a new technology is useful when the blood is insufficient, but it is an obstacle to the application of such machinery when blood is administered nationwide. If we continue to use Cell salvage, ANH or other new methods in a wide range, we will need to study and agonize how to solve the various problems mentioned so far. In addition, these new technologies are approached through evidence-based medicine as to why this expertise is needed and used in order to be accepted globally.

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