Blood Conservation Strategies

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Case Vignette

After a benchmark with other hospitals, a local cardiosurgical team learned that their bleeding and transfusion rates were relatively high compared to other institutions. In order to expand their knowledge regarding blood conservation strategies they visited other cardiosurgical centers. In one center, the surgeon took some time to perform meticulous surgical hemostasis by cauterizing all bleeding microvessels in the chest wall and during cardiac surgery. While this caused a short prolongation of the total duration of surgery, the team noticed that there was almost no microvascular bleeding at the end of surgery. Although the introduction of this approach in their own center yielded some resistance, they started with meticulous surgical hemostasis in all cardiac cases, with less oozing and blood loss as result. Surgical hemostasis has now become a routine part of blood conservation strategies in their patient blood management program.

Why Is It Important?

The essence of blood conservation in cardiac surgery consists of the principle that no blood of the patient shall leave the theater, unless it is within the patient. Blood conservation techniques must be considered synergistic and should always be applied as part of a comprehensive blood management program. Figure 14.1 shows the different aspects of blood conservation strategies during cardiac surgery. The purpose of this chapter is to describe these different strategies and their contribution to reduced bleeding and transfusion requirements.

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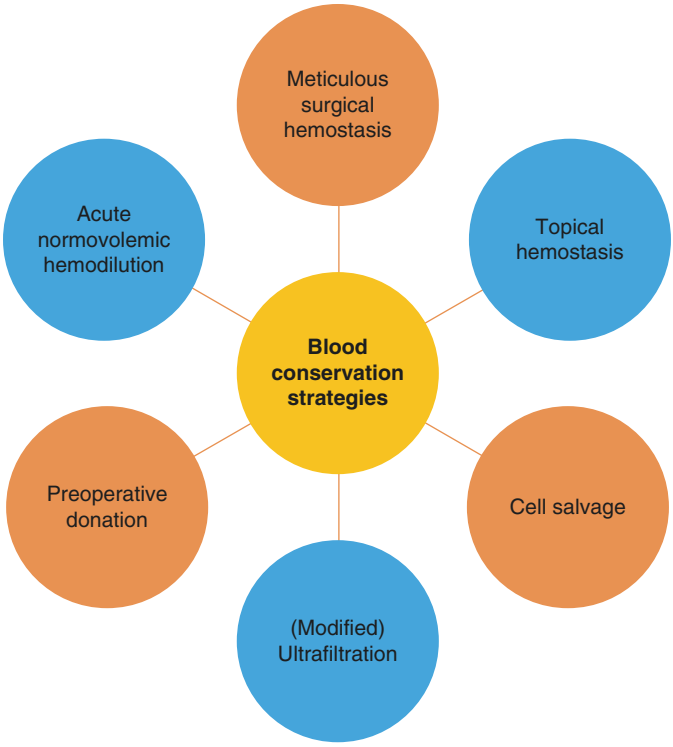

Fig. 14.1 Blood conservation strategies that may contribute to reduced bleeding and transfusion requirements in cardiac surgery

Surgical Prevention of Bleeding

Perhaps because of the obvious nature, high-level evidence on the importance of the application of a meticulous hemostatic surgical technique is scarce. Nevertheless, accurate and conscious hemostasis from incision until wound closure plays a key role in blood conservation without which all other factors are of less importance.

Topical Hemostasis

Prevention of surgical bleeding by topically applied hemostatic agents is not considered effective for routine application, because literature in cardiac surgery is highly contradictory on this matter. As standardization is difficult for topical treatment of bleeding, available literature is mostly based on animal studies. However, i.e., sealants based on polyethylene glycol polymers, a combination of bovine albumin and glutaraldehyde and a combination of gelatin and thrombin, can play an important role in hemostasis in special bleeding situations that would otherwise only be managed with great difficulty [1–3].

Cell Salvage

The use of cell salvage is currently standard practice in many centers due to several factors. Several variants of cell salvage machines are available. The basic principle of cell salvage consists of a vacuum driven suction device that mixes shed blood from the wound with washing fluid, usually heparinized saline. This mixture is suctioned to a bowl which centrifugates the blood and saline solution, thus concentrating the blood cells to a hematocrit of 60% or higher. These washed cells are then collected in a bag and retransfused using a filter to prevent infusion of clots, microaggregates, or other irregularities.

Firstly, cell salvage is considered efficacious in blood conservation and in preventing the need for transfusion [4, 5] in cardiac surgery [6, 7]. As compared to other methods of blood conservation, cell salvage can be used throughout surgery, where other methods aiming for retransfusion or concentration of patient's blood, i.e., cardiotomy suction or ultrafiltration, are limited to the phase of extracorporeal circulation. This also enhances efficacy. Due to the influence of many variables, it is difficult to quantify the advantage of cell salvage in general terms. However, one meta-analysis consisting of 31 randomized trials involving 2282 patients showed that cell salvage significantly reduced the odds ratios for any allogenic blood products and red blood cells only (OR 0.63, 95% CI: 0.43–0.94, $P = 0.02$ and OR 0.60, 95% CI: 0.39–0.92, $P = 0.02$, respectively) without indications for negative side effects [6].

Secondly, shed blood in the wound during surgery expresses an inflammatory response due to contact activation [8] which is present in the plasma. During the cell salvage process, cells are washed and the activated blood plasma is separated from shed blood from the wound. Therefore, cell salvage leads to reduced inflammatory response in comparison to cardiotomy suction [9–11], and can also result in reduced postoperative blood loss [7]. Moderate volumes of cell saved blood with the removal of the accompanying plasma in the cell salvage process do not affect postoperative hemostasis [12] as cell salvaged blood does not contain coagulation factors and platelets. However, discarding larger quantities of plasma will have a deleterious effect on the coagulation system [13]. Oxygen delivery of salvaged cells is preserved, which is not the case in allogenic blood transfusion [14, 15].

Thirdly, standard use of cell salvage is associated with extra cost for the device and the disposables. However, depending on local situations, especially the cost for disposables versus the price of blood products, which may vary per country, these expenses can be outweighed by the benefits due to savings on the cost for allogenic blood transfusions [16].

Ultrafiltration and Modified Ultrafiltration

Using a hemoconcentrator in the extracorporeal circuit, control of the total volume of blood during cardiopulmonary bypass can be achieved by means of ultrafiltration (UF). In modified ultrafiltration (MUF), excess fluid is discarded from the

remaining blood after termination of extracorporeal circulation. Blood from the arterial line and the remaining blood from the venous reservoir is led to a roller pump via a hemoconcentrator. Then, the concentrated blood is retransfused to the patient through the venous cannula in the right atrium. As hemodilution is associated with bleeding, the inverse, concentration of diluted blood, can be part of a blood conservation strategy, especially in anemic patients. Moreover, as with cell salvage, UF and MUF are accompanied by removal of mediators of inflammation and this may also lead to improved hemostasis [17–21]. However, the efficacy of ultrafiltration of residual cardiopulmonary bypass blood is not equivocal [22].

Preoperative Donation

Preoperative donation of blood that is retransfused during or after surgery may reduce the number of allogenic blood transfusions in cardiac surgery. This approach is however limited to patients with relatively high hemoglobin and hematocrit levels, a relatively large body surface area without coagulation abnormalities. It was shown that preoperative donation in elective surgery was associated with a lower occurrence of allogenic blood transfusion, but due to its retrospective nature, the study was biased by multiple confounding factors [23]. In a matched-pair analysis it was shown that retransfusion of preoperative donated blood was associated with a decrease in the overall transfusion of blood products [24]. Large randomized controlled studies on preoperative autologous blood transfusion are currently lacking.

Acute Normovolemic Hemodilution

Acute normovolemic hemodilution (ANH) is a technique in which a predefined amount of blood is taken from the blood circulation of the patient and replaced with a crystalloid solution. Blood is stored during surgery, and retransfused after the procedure. The effects of ANH on blood consumption are heterogeneous [25, 26] or at best modest [12]. This technique is conflicting with the general strategy in blood management to prevent hemodilution by fluid restriction. One guideline recommends to limit acute normovolemic hemodilution to patients with high preoperative hemoglobin levels, which can be taken into consideration [27].

Implications for Daily Practice

In summary, blood conservation during open heart surgery should primarily consist of a combination of good surgical hemostasis in combination with cell salvage. Meticulous hemostasis during opening of the chest may be somewhat time-consuming, but may reduce the time during chest closure and contribute to a reduction in microvascular bleeding. The evidence for the application of cell salvage during cardiac surgery is conflicting, and seems to be dependent on the timing of cell salvage

(shed and residual blood) and the maximum volume that is retransfused (less than 1 liter). For other techniques, like ultrafiltration, preoperative blood donation, and acute normovolemic hemodilution, the level of evidence is low, and these techniques should only be considered in patients with a clear benefit or high-risk profile.

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