Guidelines

Cell salvage for peri-operative blood conservation 2018

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Association of Anaesthetists guidelines: cell salvage for peri-operative blood conservation 2018

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Summary

The use of cell salvage is recommended when it can be expected to reduce the likelihood of allogeneic (donor) red cell transfusion and/or severe postoperative anaemia. We support and encourage a continued increase in the appropriate use of peri-operative cell salvage and we recommend that it should be available for immediate use 24 h a day in any hospital undertaking surgery where blood loss is a recognised potential complication (other than minor/day case procedures).

Recommendations

1. The use of cell salvage is recommended when it can be expected to reduce the likelihood of allogeneic (donor) red cell transfusion and/or severe postoperative anaemia.
2. We recommend that cell salvage equipment and staff trained to operate it be immediately available 24 h a day in hospitals undertaking surgery where blood loss is a recognised complication.
3. Collection of blood for potential cell salvage ('collect only' mode) should be considered for surgical procedures where blood loss may exceed 500 ml (or > 10% of calculated total blood volume) in adult patients, or > 8 $ml.kg^{-1}$ (> 10% of calculated total blood volume) in children weighing > 10 kg.
4. Each hospital should have both a nominated clinical lead and a coordinator for cell salvage, who oversee a competence-based training programme for all involved staff, along with ongoing data collection and audit.
5. When the use of cell salvage is proposed in surgery for malignancy or infection, an explanation should be given to the patient of the potential risks and benefits and specific consent should be obtained.
6. The use of leucodepletion filters should be considered during re-infusion of salvaged blood in cancer surgery and when blood is salvaged from an infected surgical field. There is mixed evidence of the benefit of leucocyte depletion filters in obstetrics.
7. Current evidence does not support the routine use of cell salvage during caesarean section. Cell salvage should be considered in the 'collect only' mode in women undergoing caesarean section who are anaemic before surgery, in women anticipated to be at high risk of haemorrhage or if unanticipated bleeding develops during surgery.

What other guideline statements are available on this topic?

These guidelines update previous Association of Anaesthetists guidelines on intra-operative cell salvage published in 2009 [1]. The National Institute for Health and Care Excellence (NICE) published guidelines for intra-operative cell salvage in obstetrics in 2005 [2] and in urology in 2008 [3]. The UK Cell Salvage Action Group has published guidance and other resources [4]. In Australia, the National Blood Authority has published relevant guidance [5]. Most recently, the NICE transfusion guidelines refer to cell salvage [6].

Why were these guidelines developed?

These guidelines were developed to inform, support and encourage the appropriate increased use of cell salvage as part of a blood conservation (Patient Blood Management) programme.

How and why does this statement differ from existing guidelines?

This guideline recommends wider use of cell salvage, and recommends that cell salvage should be universally available in hospitals performing major surgery.

Introduction

Our previous guideline on this topic was published in 2009, when cell salvage (CS) was relatively underused and devices were only just being introduced into many hospitals [1]. Since then, there has been rapid expansion in its availability and use. The aim of this guideline is to provide a practical series of recommendations to facilitate widespread use.

Although potentially life-saving, allogeneic (donor) blood is a precious resource with limited supply [7]. It is relatively expensive, and poses potential risks to the patient [8]. There has been much work to try to encourage appropriate transfusion practice and renewed interest in alternatives to allogeneic transfusion. In 2012, the National Blood Transfusion Committee, NHS Blood and Transplant and the Department of Health, launched the Patient Blood Management (PBM) initiative in England and North Wales. Patient Blood Management is an evidence-based multidisciplinary approach to the care of patients requiring transfusion, which includes: pre-

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operative haemoglobin optimisation; bloodless surgery; the use of antifibrinolytics; blood conservation techniques; and evidence-based transfusion triggers, which, if implemented, should reduce the need for allogeneic transfusion [9].

During the peri-operative care of a patient, the anaesthetist has a fundamental role in advocating PBM strategies. Cell salvage is a key part of PBM and is a relatively simple and effective blood conservation technique that reduces the requirement for and amount of allogeneic blood transfusion and maintains postoperative haemoglobin concentration. Cell salvage is a method of autologous blood transfusion. It involves the collection of shed blood during and immediately after surgery, which is re-infused back to the same patient. Intra-operative CS usually involves the use of a device which processes shed blood; however, postoperatively, unwashed filtered blood can be re-infused under certain circumstances.

Currently, NICE recommends that cell salvage is considered in operations where very high-volume blood loss is expected, such as cardiac, major (open) vascular, complex urology, obstetric and orthopaedic surgery [6]. The Association of Anaesthetists has defined significant blood loss as > 500 ml in adults [10]. A recent survey by the UK Cell Salvage Action Group suggests that CS is being used across several specialties, but that some units still face significant barriers, such as lack of staffing, training and funding [11]. Obstetric practice was the specialty where the increased use of CS was most apparent, with other specialties' usage static between 2010 and 2014.

It is our aim to support and encourage a continued increase in the appropriate use of peri-operative CS and we recommend that it should be available for immediate use 24 h a day in any hospital undertaking surgery (other than minor/day case procedures). The Working Party acknowledges that proper implementation will require additional resources for which clinical managers should work towards over time.

Principles and practice of intra-operative cell salvage

Cell salvage begins with the collection of shed blood from the surgical field. The blood is mixed with an anticoagulant, either heparinised saline or acid-citrate dextrose, as it is aspirated using a low-pressure suction into a collection reservoir, where it passes through a filter. Separation of red cells from whole anticoagulated blood occurs through centrifugation. The red cells are washed using intravenous saline 0.9% and then pumped into a bag for re-infusion to the patient. There are a variety of CS systems available. All the systems produce a comparable end-product, that is, the patient's own red cells suspended in saline.

Cell salvage should be used alongside other PBM measures. It is appropriate to use cell salvage when it can be expected to reduce the likelihood of allogeneic (donor) red cell transfusion and/or severe postoperative anaemia. Cell salvage should be considered for blood collection during every surgical procedure when blood loss may exceed 500 ml in adult patients. National Institute for Health and Care Excellence recommends CS should not be routinely used without also giving tranexamic acid [6]. It should also be considered if: the patient is at an increased risk of bleeding due to coagulopathy or other risk factors; the patient is anaemic and surgery is urgent and there is no time for active management of anaemia before surgery [9]; or the patient has a religious or other objection to receiving an allogeneic transfusion. If there is doubt about expected blood loss, then we recommend that the most cost effective measure is to set up only the suction and anticoagulation tubing and reservoir of the CS device (so-called 'collect only'). The blood processing system is then set up during surgery only if enough blood has been collected for processing to be worthwhile, usually more than 500 ml [4].

Cell salvage is commonly used during the following types of surgery: cardiac; major vascular; major hepatobiliary; major spinal surgery; arthroplasty surgery, particularly revision hip replacement; major urological surgery; surgery for thoracic, abdominal and pelvic trauma; and obstetric procedures and major obstetric haemorrhage [12].

There are no absolute contraindications to CS; however, potential contamination of the aspirated blood with bowel contents, infection or tumour cells should be regarded as a relative contraindication, depending on the likelihood/degree of contamination. In these situations, an assessment of the risks and benefits of CS should occur [13]. Patient refusal is unusual, and most Jehovah's Witness patients will accept CS – this should be discussed and documented before surgery. The equipment can usually be set up as for non-Jehovah's Witness patients, that is, without a continuous connection from the patient to the CS system and back to the patient. A history of heparin-induced thrombocytopenia is a contraindication to the use of a heparin-containing anticoagulant solution with CS. An anticoagulant solution containing acid-citrate dextrose may be used instead. Where there is temporary contamination of the surgical field with solutions that may cause red cell lysis, or drugs

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or substances that should not be given intravenously, then CS should be discontinued and the standard operating room suction system used instead. In most cases, CS may be resumed later following irrigation of the surgical field with saline.

The Working Party suggests that detailed information about CS is given to patients before surgery whenever the use of CS is planned or likely, and that patients are offered an opportunity to discuss the potential advantages and disadvantages of CS with an appropriate clinician.

Organisation of service and education of staff

Cell salvage should be integral to and embedded within surgical and peri-operative practice, and we recommend that CS equipment and staff trained to operate it be immediately available 24 h a day in hospitals undertaking surgery where blood loss is a recognised complication.

There should be a named clinical lead and nominated CS coordinator (e.g. theatre practitioner registered nurse, operating department practitioner/anaesthetic assistant, perfusionist) within the operating theatre department who are responsible for ensuring overall management and facilitation of the hospital CS service.

Every surgical and obstetric unit should have a local guideline/protocol and standard operating procedure in place. These should specify: staff training; patient selection; patient information; prescribing requirements; standards of labelling for the re-infusion bag; checks before transfusion; documentation; adverse incident reporting; quality assurance; and audit, as detailed below. National Occupational Standards should be referred to [14]. These are broad and generic standards that apply to all personnel involved in CS regardless of professional background. An adequate number of staff should be trained and skilled in the use of CS to allow service continuity throughout the 24-h period.

Although it is possible to have dedicated CS operators, it is more common for theatre staff or a perfusionist to undertake this as part of their role. Staff involved in CS must be trained and assessed as competent in the set-up and use of equipment. In some hospitals, clinical support workers have been trained to set up CS equipment, but not trained in its use. Records of training and assessment should be collated and maintained by the service coordinator, and individuals should be encouraged to include them in their professional portfolios, which must be kept within the department and as part of individual records. Local policy should define which roles within the CS team require what training and how frequently retraining is required, in line with established guidance [4].

The individual practitioner is responsible for working within their professional boundaries and sphere of competence [15]; CS operators should maintain a clinical log of cases. In hospitals where there is a low level of CS activity, it is the responsibility of the individual and their manager to identify additional and appropriate opportunities to maintain competence and clinical currency. This may be achieved through simulation or collaborative working with other organisations. Additionally, maintenance of training and competence records by the employing organisation is fundamental to safe working practices.

In addition to the theoretical knowledge, it is essential that practical, skills-based training is undertaken to familiarise individuals with equipment and procedures for use [4, 16], followed by assessment of competence. Training specific to equipment may be provided by the manufacturers or designated local trainers. However, manufacturers are not able to assess for competence in clinical practice – this remains the responsibility of the employing organisation.

Whenever CS is used, this should be accurately clinically coded to meet the approved NHS Fundamental Information Standard (SNOMED-CT code 233568002). This will enable appropriate reimbursement of the service and improve data collection and audit [17]. The Working Party recommends that relevant data should be continuously collected and audited regularly. Regarding quality assurance, we suggest the following are regularly reviewed: maintenance contracts and regular servicing of the machines; interval sampling of blood produced by CS for laboratory testing of haemoglobin concentration; and log of authorised personnel including records of training and assessment [4].

The Working Party suggests that the World Health Organization (WHO) checklist should include the mention of CS when required when discussing haemorrhage, and that this should be reflected in local policies. The use of CS and infusion of salvage red cells in the operating theatre should be clearly documented, and any red cells for re-infusion outside the operating theatre should be authorised by the responsible clinician. A minimal data set for labelling the re-infusion bag and collection reservoir must include the patient's full name, date of birth, unique identification number, expiry date and time of the salvaged blood (on the re-infusion bag) [4].

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Technical aspects

The cell salvage system should be used according to the manufacturers' instructions and should be routinely run in automatic mode if available. There are several different suction devices [18] and different machines [19] on the market, and staff should be appropriately trained in the equipment used in their institution. Within an institution, it is preferable to use only one type of CS machine to maximise familiarity and experience. To reduce haemolysis, the vacuum pressure should always be set as low as practicable. Typical values are between −100 and −150 mmHg, and excess pressures should be avoided to minimise red cell lysis [4]. In the event of rapid blood loss, the vacuum level can be temporarily raised to clear the surgical field and then reduced to a lower level for lower flows.

The re-infusion of salvaged blood should be completed within the manufacturers' recommended time frame; this is usually 4 h after the completion of processing for intra-operative cell salvage and 6 h after the start of collection for postoperative cell salvage. In addition, the bag of processed blood should not be placed in a blood fridge and should be kept beside the patient at all times. If heparinised saline is used as the anticoagulant solution, care must be taken to add the correct volume and concentration of heparin and label the bag clearly so that it is not accidently given intravenously. If there is rapid blood loss and the CS system is operated in manual or emergency mode, or in the case of operator error, excessive heparin may be given back to the patient in the re-infused blood, resulting in anticoagulation and increased bleeding. In this case, the activated clotting time (ACT) or activated partial thromboplastin time (APTT) should be checked, and if elevated (e.g. ACT > 125 s), protamine may be given. An alternative to heparinised saline is acid-citrate dextrose, which is available in pre-prepared bags. In case of rapid blood loss or operator error, significant quantities of citrate may be re-infused along with the salvaged blood and, as with the citrate present in allogeneic blood components, this may cause hypocalcaemia requiring calcium administration.

When re-infusing processed red cells, bed-side checks before transfusion should be performed in the same manner as for allogeneic blood. A standard blood administration set with an in-line blood filter should be used. Pressurising re-infusion bags presents a risk of air embolism and is not recommended. All single-use equipment should be disposed according to the local health and safety policy. The machine should be cleaned in accordance with the manufacturers' guidance and local infection-control policy.

There should be an audit log completed and kept in the department attached to each machine. Serious adverse events and reactions should be reported to the clinical lead and the Hospital Transfusion Committee, and, if appropriate, a report should be completed and sent to Serious Hazards of Transfusion (SHOT, http://www.shotuk.org/) and /or the Medicines and Healthcare products Regulatory Agency (MHRA, https://www.gov.uk/government/organisations/medicines-and-healthcare-products-regulatory-agency), as appropriate.

Obstetrics

Obstetric haemorrhage is a significant cause of maternal mortality and the most report showed an increase in deaths – almost double the rate – from haemorrhage, mainly attributable to abnormal placentation [20]; it also remains a leading cause of maternal morbidity in the UK [21]. National surveys show that CS is a resource that is being used more frequently in UK obstetric units [22]. Re-infusion rates and cost effectiveness are variable and directly associated with larger volumes of blood loss [23]. Despite the growing availability of equipment and safety endorsements for its use, challenges remain in providing CS in an obstetric surgical setting. Haemorrhage associated with emergency operative delivery is often not predictable, rapid and occurs out of hours.

The SALVO trial (cell salvage during caesarean section: a randomised controlled trial) is the largest study to date (n = 3054) examining the role of CS in caesarean section [24]. SALVO did not find a significant difference in donor transfusion rate in caesarean section or a cost benefit argument for routinely setting up a complete collection and retransfusion system. However, institutional level costs are still dependent on case volume, expected levels of blood loss per case and initial investment costs [25]. Use of strategies such as swab washing to improve collection rates should be considered to contribute to the complex analysis of cost effectiveness locally [26]. Furthermore, although SALVO's exploratory analysis in cases of malplacentation did not demonstrate effectiveness, the trial cannot be used to justify or refute the use of CS in cases of anticipated torrential haemorrhage. As in previous studies, there is evidence of fetomaternal haemorrhage, which supports the concerns regarding increased risk of haemolytic disease in future pregnancies. The group recommends further research on the long-term consequences of allo-immunisation to RhD and

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other red cell antigens following the use of CS and emphasises the need for strict adherence to anti-D guidelines in units using CS.

Use of leucocyte depletion filters and the requirement for separate suction for blood have now been questioned by some advocates of the technology A double suction technique – one waste sucker for amniotic fluid and another sucker attached to the cell salvage device for suctioning any blood lost – may reduce initial contamination, although in-vitro evidence consistently demonstrates that the cell salvage/filtration process can effectively remove plasma phase elements of amniotic fluid whatever the initial load [27]. Use of leucocyte depletion filters (LDF) should be considered but these slow re-infusion rates and evidence for their effectiveness in this setting is mixed [28]. Because they are adhesion filters, blood cannot be forced through them and they may become saturated during use, requiring replacement, and have the potential to cause bradykinin-mediated hypotension. The Working Party decided not to recommend routine use of double suction or LDFs in obstetric practice.

Therefore, the Working Party recommends that CS is not used routinely for caesarean section based on the current evidence, be it elective, urgent or emergency. Cell salvage should be considered in 'collect only' mode in patients who are anaemic before surgery or if there is unanticipated ongoing bleeding during surgery. If a decision is made to use it because a woman declines autologous transfusion or significant blood loss is anticipated, the risk and benefits should be discussed with the woman.

Cell salvage during cardiac and vascular surgery

Cardiac surgery accounts for approximately 6% of all blood transfused in England and Wales [28], due to frequent major surgical blood loss exacerbated by coagulopathy and impaired platelet function associated with cardiopulmonary bypass. Cell salvage during cardiac surgery is widely accepted; a meta-analysis of 31 trials showed that routine use reduced the transfusion of red cells by 40% [29].

Blood lost before and after bypass, when the patient is not heparinised, is wasted unless cell salvage is used. However, during bypass, when the patient is heparinised, cardiotomy suckers are used to collect any blood from the surgical field, which is passed through a filter and returned to the bypass reservoir and then the patient's circulation. There has been some research into the use of CS during bypass, instead of the use of cardiotomy suckers. However, the use of CS during bypass, compared with direct suction into the cardiotomy reservoir, results in depletion of clotting factors and platelets, and is therefore not recommended.

After bypass, around 500–1000 ml of blood will be left in the bypass circuit and reservoir. It is commonplace to return this unprocessed blood to the patient, but there is some evidence that processing this by separation and washing of red cells using a cell salvage system, thereby concentrating the red cells and increasing the haematocrit before re-infusion, may be beneficial in terms of reduction in requirement for allogeneic blood [30]. However, centrifugation of residual bypass pump blood is also effective in increasing the haematocrit before re-infusion [31]. Other blood concentrating devices have not been shown to be effective [32]. We recommend that cell salvage, if already in progress, be used to concentrate residual bypass pump blood before re-infusion; alternatively, the use of centrifugation under these circumstances is reasonable [31].

Some centres in the UK routinely use cell salvage throughout cardiac surgery. However, there is conflicting evidence for cost effectiveness during lower-risk surgery such as primary coronary bypass or single valve surgery [33]. We recommend the use of cell salvage, at least in 'collect only' mode, for all cardiac surgery. If blood collected is > 500 ml, this can be processed and returned to the patient. Cell salvage is recommended whenever cardiac surgery is performed without the use of bypass ('off-pump').

The use of cell salvage during open aortic surgery is also well established. It has been shown to be safe, and a meta-analysis has shown that the use of cell salvage may reduce the risk of red cell transfusion by 37% in patients undergoing elective abdominal aortic aneurysm (AAA) repair [34]. A study in emergency AAA surgery showed that up to three units of red cells may be saved per patient and that hospital mortality was reduced [35]. We recommend that cell salvage is used routinely for all open aortic surgery, and considered for all vascular surgery where > 500 ml blood loss is expected.

Orthopaedics and trauma

Data from 19 years and more than 2 million total joint arthroplasties revealed that there was an increase in red cell transfusion until 2011 and that this was associated with an increase in morbidity [36]. In a meta-analysis of RCTs that included hip and knee arthroplasties, intraoperative CS significantly reduced red cell transfusion

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exposure rate and the volume of allogeneic red cells transfused [37].

Intra-operative CS should be considered in all patients undergoing orthopaedic or trauma surgery when blood loss is expected to be > 500 ml. If bone cement is used, then CS should not be used while cement is being applied and can be resumed when the cement is fully set. For revision surgery, when metalwork may be in situ, such as previously instrumented spinal surgery, there is evidence that standard 40 micron filters do not eliminate the smallest fragments of titanium, so caution should be exercised [38]. However, we still recommend that CS is considered in such cases, with the proviso that standard suction is used until the surgical field has been irrigated and all metal fragments removed. Also, CS should not be used while the surgical field is contaminated with antibiotics, iodine or topical clotting agents, but its use may be resumed once these have been washed away.

Cell salvage is particularly useful in operations where a tourniquet cannot be applied, such as hip arthroplasty or spinal surgery. When tourniquets are used, for example, in knee surgery, the CS equipment can be set up for use once the tourniquet has been released and re-infusion can take place in the postoperative period. Alternatively, blood collected via drains postoperatively can be re-infused, with or without processing.

A Cochrane review comparing CS with standard care in patients undergoing abdominal or thoracic trauma surgery found that the use of CS resulted in the transfusion of 4.7 (95%CI 1.3–8.1) fewer units of allogeneic red cells [39]. It concluded that CS in this setting reduces blood transfusion and is cost effective. Prospective data for 30 patients [40] undergoing pelvic acetabular fracture fixation found a mean blood loss of 1233 ml and an average of 388 ml retransfused through CS; only 47% of patients required allogeneic transfusion. In a combat hospital, a CS feasibility study concluded that CS was most successful in patients with gunshot wounds and cavity injuries compared with limb or blast injuries [41].

In a dedicated trauma/emergency operating theatre, we recommend that a CS machine and staff trained to operate it should be immediately available at all times.

Paediatrics

Complications of allogeneic blood transfusion in children and infants may be more common than in adults [42]. Pre-operative autologous donation in children has both practical and complex logistical problems that make it costly and of uncertain benefit [43]. Cell salvage should be used as part of a comprehensive Patient Blood Management programme [44]. Cell salvage is used most frequently in spinal surgery (larger children or adolescents), during cardiac surgery [45], liver transplantation and cranio-facial surgery [46]. Cell salvage may replace or reduce the transfusion of allogeneic blood, depending on the clinical circumstances.

The expected blood loss (EBL) to blood volume (BV) ratio (EBL/BV) that might mandate the use of CS varies in the paediatric literature from 10% to 40%, and this reflects local practice and equipment availability. The Working Party recommends that CS should be considered at least in 'collect only' mode when blood loss > 8 $ml.kg^{-1}$ (equivalent to approximately > 10% of total blood volume) is anticipated and the child's weight is > 10 kg [47].

Some CS devices collect aliquots of blood in a bowl that must be filled before washing to retrieve the blood, and in many cases the volume retrieved is insufficient to be processed. This can be obviated in different ways: the volume lost can be drained into a receptacle in the surgical drape that has been prepared with heparinised saline and this can be drained and washed once a certain volume has been shed; a smaller volume bowl can be used; a partially filled bowl can be processed; or a continuous auto-transfusion system (CATS™, Fresenius Kabi, Runcorn, UK) can be used that is not dependent on collecting intermittent, large aliquots of blood. Whether there is a practical difference between these approaches has been questioned [48].

The cost effectiveness of cell salvage in children has been examined. Samnaliev et al. examined the costs and benefits of cell salvage in 478 children undergoing cardiac or orthopaedic surgery at Boston Children's Hospital, who qualified for CS according to local protocol [49]. They concluded that CS was the most cost-effective strategy, although half of the children in whom CS was used also required transfusion of allogeneic blood. Golab et al. suggested that although CS was safe and reduced allogeneic transfusion, it was costly [45]. Cholette et al. [50] did not critically examine cost. Differing disposable and staff costs in different institutions may alter the cost but the reduction in allogeneic transfusion is clear.

Postoperative cell salvage

Patients may continue to bleed postoperatively, and the use of drains to prevent accumulation of blood is commonplace after many surgical procedures. Blood collected via drains can potentially be re-infused. Two types of postoperative blood salvage systems are available. Washed postoperative red cell salvage involves the

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collection of blood from which the red cells are separated by centrifugation and washed with saline in the same manner as for intra-operative cell salvage. In unwashed/filtered postoperative blood salvage, blood is collected and re-infused through a filter without centrifugation or washing.

A Cochrane review analysed 29 trials on postoperative cell salvage after cardiac and orthopaedic surgery [12], and showed a 41% reduction in allogeneic red cell transfusion (RR 0.59; 95%CI 0.48–0.73).

Re-infusion of recovered blood, with or without washing, after orthopaedic procedures is safe and economical [51]. Unwashed postoperative blood salvage may be used after orthopaedic surgery, particularly total knee arthroplasty, and has been found to reduce exposure to allogeneic red cell transfusion [6].

After cardiac surgery, blood collected via the chest drains must be processed through a cell salvage system before re-infusion due to accumulation of fat and other contaminants that are removed by the cell salvage process. We recommend that (washed) CS be considered in patients who bleed > 100 $ml.h^{-1}$ in the first 6 h after cardiac surgery, and whenever resternotomy is required for haemorrhage [4, 5].

Cancer surgery

Despite theoretical concern, there is no absolute contraindication to CS in cancer surgery. Its use is controversial because malignant cells are often present in the operative field, can be found in salvaged blood and may, theoretically, metastasise after re-infusion. Circulating malignant cells are often present in cancer patients undergoing surgery, regardless of CS use, and very few of these cells are thought capable of causing metastases [52]. The number of malignant cells in salvaged blood can be reduced by the use of LDFs, with no apparent adverse effect on the quality of the product [52]. The use of LDFs has not been shown to be associated with either bradykinin or leukotriene generation in cell-salvaged blood [53]. Cell salvage may reduce or eliminate exposure to allogeneic blood, which has been associated with immunosuppression and cancer recurrence [54]. One major disadvantage of LDFs is that the rate of flow through them is considerably slower, and therefore clinicians may need to assess the benefit of quicker transfusion without a LDF vs. its use.

In summary, despite theoretical risks and benefits, there is no conclusive evidence that CS can induce metastases or affect cancer prognosis [55]. The theoretical risk of inducing metastatic spread (unproven) is offset by reduced allogeneic transfusion and immunomodulation, which is proven. As a result, many clinicians do offer cell salvage to patients undergoing major cancer surgery. The Working Party recommends that potential risks and benefits should be discussed with patients before cancer surgery, and specific consent obtained.

Infected and contaminated fields

There is no absolute contraindication to CS in this setting. Its use is, however, controversial, because CS might (theoretically) worsen sepsis by introducing infective agents and toxins recovered in the operative field. Conversely, CS reduces exposure to allogeneic blood, which may increase the incidence of postoperative infection through immunomodulation [56, 57]. Washing of collected blood and the use of LDFs removes most bacteria, but this effect is probably dependent on the level of contamination [58]. There is no conclusive evidence that CS worsens sepsis, prognosis or the risk of other specific complications when used in contaminated fields, including major trauma surgery.

We recommend that the use of cell salvage in cancer surgery and infected fields should be considered on a case by case basis. Whenever possible, patients in whom cell savage is used should be counselled and asked whether they consent to the procedure being used. Leucodepletion filters should be used for blood re-infusion.

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