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# Autotransfusion: Therapeutic Principles, Efficacy and Risks

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## 1. Introduction

The safety of allogenic blood products has been increased in the following ways: strict rules for donor selection following new insights in infectious; testing of donor blood with techniques to minimise window-period; reduction of leukocyte-count of blood products (in some countries); introduction of disinfectant techniques of plasma; introduction of quarantined plasma; culture of thrombocyte products. Other adverse effects, such as transfusion reactions, human errors, graft versus host disease, alloimmunisation, signs of an increase in nosocomial infections, as well as a possible immunosuppressive effect have contributed to the demand for alternative blood products or techniques decreasing the transfusion of allogeneic blood products, the so-called “blood-saving techniques”. To reach this goal, these techniques can be used separately. However, in most cases a combination of several methods will be employed, often referred to generally as “blood management”.

Momentarily, both pharmacological and non-pharmacological methods are available. Each technique has its’ own efficacy. Each technique however, may also carry its’ own adverse effects or complications. Most adverse effects are published in case reports or retrospective studies. Literature published studying aprotinin shows the importance of controlled randomised trials or cohort studies large enough to detect the incidence of adverse effects and to measure any differences in side effects. At the moment, haemovigilance for blood transfusion saving techniques is not regulated. However, the Dutch experiences highlight the importance of awareness of adverse effects.

Autotransfusion (red cell salvage) is one of these techniques and involves the infusion of blood collected intra-operatively from the operative field, or postoperatively from the drains, and will be discussed in this chapter. This method is one of the most commonly used techniques of autologous blood transfusion. The collected blood can be re-infused either directly or after filtration of cellular and other debris via a blood cell separator, referred to as the “washed method”. In this chapter, efficacy, quality and safety of both methods will be described.

## 2. Definitions of the different techniques

### 2.1 Unprocessed or unwashed method of autotransfusion

This is the oldest technique, first suggested in 1818 by James Blundell and first performed by Brainard in 1860 (Blundell 1818, Brainard 1860, Koopman 1993). Blood is collected under

low vacuum pressure ( $< 100$  mm Hg) in a container and in most cases only filtered through a 170 micron filter. Several pore-sized filters are now available on the market. Originally this technique was also used intra-operatively, but because of serious adverse effects during reinfusion it was, until recently, only used for reinfusion of wound blood lost in the postoperative phase (drain blood) (Stachura et al. 2010 ). The blood is predominately collected without addition of anticoagulants, because the added anticoagulant is not removed by washing, and anticoagulant other than citrate may cause coagulopathy. Due to the risk of bacterial growth in the collected blood maintained at room temperature, collection and reinfusion is advised to be completed within a time span of a maximum of six hours. In cardiac surgery, longer periods of holding at lower temperature have been applied without complications (Schmidt et al. 1998). Unwashed techniques are not advised for children.

## 2.2 Processed or washed methods of autotransfusion

With this approach, anticoagulant (heparin or citrate) is added to the tip of the vacuum by means of a double-lumen suction catheter. The aspirated blood is filtered through a 170 micron filter. Thereafter, the blood is centrifuged in a blood cell separator, removing the plasma which contains cell remnants. The remaining erythrocytes are washed with a saline solution and infused through a 40 micron blood filter. Postoperatively, the drain-blood, with or without anticoagulant, can be collected and processed in a time span of 6 hours. There is no limit to the amount of reinfusion of washed salvaged blood. One has to realise that only erythrocytes are recovered and consequently, massive blood loss replacement of plasma and platelets must be done by means of allogeneic blood products. For children devices available to process smaller volumes of blood are available.

## 3. Quality of the recovered blood

When blood comes into contact with non-endothelial tissue, due to the activation of the coagulation and complement cascade, platelets and leukocytes are activated and erythrocytes are destroyed (Krohn et al. 2001, Sinardi et al. 2005 , Stachura et al. 2010). Aspiration of blood increases this damage by air contact and turbulence. The amount of haemolysis depends on the type of surgery. Suction of a small amount of blood increases the risk of haemolysis and reduces the efficacy of erythrocyte recovery. The infusion of activated proteins and damaged cells may cause serious organ damage (Faught et al. 1998). Moreover, aspirated blood must be anti-coagulated with a high-dose heparin or citrate to prevent clotting which, without removal, may cause coagulopathy.

Complications described include Acute Respiratory Distress Syndrome (ARDS), Disseminated Intravascular Coagulopathy (DIC), renal failure, Multi Organ Failure (MOF) (so-called "blood-salvage" syndrome), air embolism and coagulopathy (Bull & Bull 1990, Tawes & Duvall 1996). Washing of the blood product prevents these complications.

Blood collected postoperatively from wound-drains is less activated. The recovered blood contains free haemoglobin (Dalén 1995, 1997), activated cells, and mediators of the activated coagulation pathway. These factors can be measured in recipient's plasma. Dalén showed that approximately 0.5% of the recovered erythrocytes in drain-blood are haemolysed (Dalén & Enström 1998, 1999). The haematocrit level is lower in drain-blood due to dilution with chyle. Filtration of drain blood through a leukocyte-reducing filter previous to

collection in the container, and avoiding filtration after collection, may reduce erythrocyte damage (Dalén & Enström 1998, 1999).

Unwashed drain-blood contains no fibrinogen and therefore addition of anticoagulant should not be necessary. However, clot-formation in the recovered blood has been described in 0,3 % of cases (Horstmann et al. 2010). Generally, no obvious clinical side-effects have been shown, but confusion may arise with diagnostic tests e.g. biochemical confirmation of myocardial infarction (Pleym et al. 2005).

The suction tip and the collection bag may be a cause of bacterial contamination (Wollinsky 1997), but antibiotic prophylaxis is generally effective. If autotransfusion is applied following advised methods, bacterial contamination is not a major risk (Wollinsky et al. 2007, Bowley et al. 2006).

### 3.1 Quality of the recovered erythrocytes

The efficacy of erythrocyte recovery is determined by the type of surgery, suction-technique, the pressure of the vacuum, and the prevention foaming and turbulence of the aspirated blood. Aspiration of small volumes destroys more erythrocytes than aspiration of larger volumes. Depending on these factors, recovery of erythrocytes is between 65% (e.g. orthopaedic) and 95% (e.g. vascular surgery) (Koopman 1993). Filtration of the collected drain-blood through a leukocyte-filter before collection in the container also reduces erythrocyte damage (Jensen et al. 1999), in contrast to filtration after collection of the blood. The haematocrit of a bag of washed red cells is approximately 0.50 l/l, slightly less than that of stored allogenic erythrocytes (Ht 60 l/l). Due to haemolysis during the suction process, regular measurement of the patient's haemoglobin level is advised.

The survival of recovered erythrocytes is normal and seems uninfluenced by the different types of autotransfusion or the type of surgery (Thorley et al. 1990, Kent et al. 1991, Wixson et al. 1994). Room temperature incubation of drain-blood causes lactate formation and swelling of the erythrocytes. Some older studies show that the osmotic resistance and 24-hour survival of stored erythrocytes after processing in a cell saver is slightly decreased (Marcus et al. 1987, Schmidt et al. 1996) compared to fresh recovered wound-blood, but more recent studies found no difference (Alleva 1995, Schmidt et al. 1996). Oxygen delivery and 2,3-DPG levels are not influenced by cell salvage or processing (McShane et al. 1987, Schmidt et al. 1996). The function of recovered leukocytes and platelets is marginally investigated, but may be depressed (McShane et al. 1987).

### 3.2 Washing efficacy

Processing of salvaged blood by means of centrifugation and washing removes most free haemoglobin and anticoagulant, 95 and 98%, respectively (Koopman 1993). Even in massive transfusions of more than 100 units of salvaged red cells, just 5000 IU of heparin are re-infused. Most modern devices have a haemolysis sensor controlling the wash procedure. This is of great import, reducing the amount of free haemoglobin infused, thereby reducing excretion in the renal tubules and the risk of acute renal failure.

Fat embolism is a complication due to aspiration of fat particles, orthopaedic surgery displaying the highest risk. Fat globules may adhere to the tubing and/or filters and are of

no risk for patients (figure 1). However, fat particles  $< 40$  micron will be infused to the patient, unfiltered. A surface- or fat-filter is more effective than a screen-filter. A leukocyte filter is the most favourable (Ramirez et al. 2002, de Vries et al. 2003, 2006), but decreases reinfusion flow greatly.



Fig. 1. Fat in the tube infusing blood from the reservoir into the blood cell separator processing bowl (arrow)

Salvaged blood of patients recovered from the area on and around a disfunctioning hip prosthesis may contain Cobalt or Chromium - washing of the salvaged blood removes, respectively, 76.3 and 78.6% of the content (Reijngoud et al. 2009).

In cardiac surgery, heart enzymes are recovered in the salvaged blood. Diagnosing perioperative complications such as myocardial infarction will be subject to error. The troponin level remains, however, uninfluenced and is therefore the most reliable indicator (Pleym et al. 2005).

#### 4. Adverse reactions

As mentioned, reinfusion of aspirated unprocessed salvaged blood can induce serious organ damage such as ARDS, DIC, renal failure, MOF or coagulopathy. Filtration and washing largely removes toxic factors and reduces complications. Due to operating errors, however,



serious complications are reported (Faugt et al. 1998, Zijlker et al. 2011). Most research has been published investigating the safety of reinfusion of unwashed drain-blood. A Dutch study of 1819 patients undergoing orthopaedic surgery showed adverse reactions in 3.6% of cases (Horstmann et al. 2009). Most reactions were mild, such as fever ( $> 38,5^{\circ}\text{C}$ ) and shivering. Two patients experienced a severe adverse reaction: cardiac arrest and atrial fibrillation due to a pulmonary embolism subsequent to reinfusion of 30 and 50 ml of autologous drain-blood, respectively. Both patients survived. Other authors describe mild adverse reactions (So-Osman et al. 2006, Kirkos et al. 2006, Hendrych 2006). Some found no relationship (Faugt 1998, Moonen et al. 2008). Reinfusion of IL-6 may be a contributing factor. A 7-fold increase in normal baseline levels has been found (Handel et al. 2006). Filtration by means of a leukocyte-filter has been shown to reduce the level of interleukins but may actually instigate complement activation during the filtration process itself (Dalén & Engström 1998).

Reinfusion of unwashed blood had no effect on lung perfusion (Attinel et al, 2007). However, there was a slight decrease in thrombocyte levels found (de Jong et al, 2007).

A study of 120 patients investigating the immunological response to several methods of blood transfusion showed a decrease in Natural Killer (NK-) cells and interferon gamma levels by all methods except reinfusion of unwashed drain-blood, which saw an increase (Gharehbaghian et al. 2004). The IL-10 levels did not change. Gharehbaghian argues that higher concentrations of interferon gamma or NK-cells indicate a more favourable immunological response.

Reinfusion of unwashed drain-blood is often used in the context of cardiac surgery. However, recent studies showed greater haemodynamic instability, probably caused by infusion of the abovementioned cytokines and activated complement (Marcheix et al. 2008, Boodwhani et al. 2008). Moreover, increases in cognitive dysfunction (15 vs. 6%) after unwashed autotransfusion have been witnessed (Djaiani et al. 2007). Laboratory values showed increased indicators of fibrinolysis or DIC (Krohn et al. 2001, Sinardi et al. 2005). These changes seemed to be clinically irrelevant in general, but some authors showed an increase in postoperative blood loss in cases of reinfusion of  $>750\text{ml}$  (Schönbergen et al. 1992, Wiefferink et al. 2007). Not all authors confirmed these results (Schroeder et al. 2007, Sirvinskas et al. 2007). Washing of the salvaged blood prevents these adverse events and is obligatory for processing intra-operative aspirated blood. Furthermore, in cardiac surgery this can be extended to drain-blood collected postoperatively.

There is no literature referring to the maximum amount of drain-blood that can be re-infused unwashed. In most studies, a mean of 500 ml is re-infused. Greater than 1500 ml is re-infused in just a handful of cases, 0.5% (Huët 1999, Horstman 2010). Some authors advise a maximum of 15% of circulating volume (Krohn et al. 2001, Sinardi et al. 2005). Therefore, a guideline could be a maximum 15% of the circulating blood volume, with a cut-off value of 1500 ml. In addition, reinfusion of collected drain should be performed following filtration of the blood through a 40 micron filter. For children, there are no data available. However, re-infusion of unwashed blood is not advisable.

A preventable complication is air embolism, particularly when blood is infused under pressure (Faugt et al. 1998). As reinfusion bags and tubing from all systems contain air, an air detector placed in the infusion system is then mandatory.

5. Indications

Perioperative autotransfusion may be indicated for all operations with great blood loss. Most experiences are in the context of vascular surgery. In a retrospective study of 9918 patients, Giordano (Giordano et al.1993) concluded that cell salvage an efficient method of reducing use of allogenic blood transfusions. Most randomised studies, however, are conducted in cardiac, vascular or orthopaedic surgery (Carless et al. 2010; table 1). For all other types of surgery, data regarding efficacy is sparse.

Author and study protocol	Study groups	Results	Adverse events	Level of evidence
Carless 2010 Cochrane CD 001888	1966-2009  75 RCT: - ortho: n = 36 - Cardio: n = 33 - Vasc: n = 6  Washed: n = 27 Unwashed: n = 40 Other: n = 8  BT-protocol: n = 60 - 75 55 x postop. - 76 21 x intra- and postoperative  No BT-protocol: n = 15  Patients: n = 3857	Overall: RR = 0.62  Ortho: RR = 0.46 - 77 washed: RR = 0.48 - 78 unwashed: RR = 0.47  Cardio: RR = 77 - 79 washed: RR = 0.66 - 80 unwashed: RR = 0.85  Vasc: RR = 0.63 n.s.  BT-protocol: RR = 0.61 No BT-protocol: RR = 0.56  Mean 0.68 EC less	Mortality, re-operations, (wound) infections, thrombosis, stroke, myocardial infarction, hospital stay: n.s.	A1

Abbreviations: Ortho = orthopedic; Cardio = cardiology; Vasc = vascular surgery; B.T. = Blood Transfusion; N.S. = Not significant; RCT = Randomised Controlled Trial; RR = Relative Risk for allogeneic blood transfusion

Table 1. Meta-analysis 75 RCT.

5.1 Autotransfusion during cardiac surgery

Reinfusion of intra- and postoperative collected blood reduces the need for allogenic blood transfusions (Ferrari et al. 2007, Klein et al. 008). Washed techniques are more efficacious (RR washed 0.61 vs. unwashed 0.87) (Huët et al.1999, Carless et al. 2010). Most complications, such as increase in bleeding and cognitive dysfunction, are described under unwashed methods (see 4.0). In conclusion, washed techniques reduce adverse events, especially the frequency of cognitive dysfunction up to > 50% (Carrier et al. 2006, Westerberg 2005, Djaiani et al. 2007, Svenmarker et al. 2004). In cardiac surgery this should be state-of-the-art.

## 5.2 Autotransfusion in orthopaedic surgery

Reinfusion of intra- and postoperative collected blood is in most studies an efficacious method of reducing the need for allogenic blood transfusions. (Huët et al. 1999, Tylman et al. 2001, Jones et al. 2004, Carless et al. 2010, Tsumara et al. 2006, Smith et al. 2007, Zacharopoulos et al. 2007, Amin et al. 2008, Tripkovic et al. 2008, Munoz et al. 2011). The haematocrit of drain-blood is approximately 0.25-0.30 l/l due to mixture with chyle. The Cochrane analysis shows an RR of 0.48 for washed techniques vs. 0.47 for unwashed techniques (Carless et al. 2010). A disadvantage is the lack of inclusion of transfusion protocol in all trials. Moreover, surgical techniques have changed in the last few years, questioning the validity of older studies, as shown in our recent multicenter, randomised study of 2579 patients (So-Osman et al. 2011).

Approximately 75% of postoperative blood loss occurs in the ensuing 6 hours, falling within the 6-hour window recommended for re-infusion (Wood et al. 2008). Wood also showed that increase in the collection time leads to augmented wound healing.

## 5.3 Autotransfusion in vascular surgery

Although intra-operative autotransfusion is most widely used in vascular surgery, and yet few randomised studies (Wong et al. 2002, Takagi et al. 2007, Carless et al. 2010, Huët et al. 1999) have been published. Adverse events are never published.

## 5.4 Autotransfusion in obstetrics

Autotransfusion of washed shed blood may be used for Extra Uterine Pregnancies (EUP) or caesareans. Use of a cell saver for EUP improved the haematocrit level at discharge significantly (Thomas D. 2005, Selo-Ojeme & Feyi-Waboso 2007, Allam et al. 2008). In the past, intra-operative autotransfusion during obstetric haemorrhage has been discouraged because of the risk of amniotic fluid embolism. Reinfusion of amniotic fluid may cause amniotic fluid syndrome with DIC, ARDS and sometimes death. Recent literature, however, shows that harmful substances are removed during the washing process (Thomas D. 2005). A consequence of leukocyte filtration is improved removal of all foetal substances in all cases. Foetal erythrocytes are present in amniotic fluid with subsequent induction of irregular antibody formation in the mother after reinfusion. However, the quantity of foetal erythrocytes seems comparable with that circulating normally amount normally circulating in the mother's blood during delivery. Use of unwashed techniques is inadvisable.

## 5.5 Autotransfusion in urology

Autotransfusion of washed unirradiated shed blood is often employed during cystectomies and prostatectomies (Nieder et al. 2004, 2007, Davis et al. 2003, Ford et al. 2007, Gallina et al. 2007, Stoffel et al. 2005, Waters et al. 2004). In these studies, blood was collected from the surgical field subsequent to prostatic manipulation. Stoffel performed measurements of the Prostate Specific Antigen (PSA) in subjects' blood: 1 hour prior to surgery; immediately subsequent to reinfusion of the shed blood; and 3-5 weeks following surgery (Stoffel et al. 2005). He also measured the PSA level in the processed salvaged blood. He found PSA expressing cells in 88% of the samples of the salvaged blood and in 13% of the preoperative



samples. Furthermore, PSA-expressing cells were found in 16% of the autotransfused patients and in 4% of the non-autotransfused patients, immediately following transfusion. No PSA-expressing cells were detected in the peripheral blood samples taken 3-5 weeks postoperatively. Authors suggest PSA expressing cells are damaged by processing of the blood and the damaged cells are removed by the immune system of the subject.

### 5.6 Autotransfusion in traumatology

Autotransfusion is often applied during trauma surgery, especially in cases of liver or splenic ruptures. In this field, just one randomised study has been published, subjects experiencing abdominal trauma in combination with bowel perforations ( $n = 44$ ; Bowley et al. 2006). Bowel perforation is generally considered a contraindication to autotransfusion. Somewhat unexpectedly, this study displayed no difference in survival or complications. However, necessity for erythrocyte transfusions was significantly less (6.47 vs. 11.17U). All operations were performed with antibiotic prophylaxis. Grossly contaminated blood with faeces or other debris was collected in a separate reservoir and not used for autotransfusion. In conclusion, this study shows that in emergency situations with abdominal trauma, washed autotransfusion may be used, provided that is under antibiotic prophylaxis.

### 5.7 Jehovah's Witnesses

Many Jehovah's Witnesses accept the use of perioperative autotransfusion provided that the machine is transformed to a closed system such as a heart-lung machine, and is completely filled with a saline solution prior to commencement of the procedure, and connected to the patient by means of an intravenous line. Some contraindications may be relative in this situation when autotransfusion may increase survival (McInroy 2005, Van Wolfswinkel 2009, Wooley 2005,). In the context of operative treatment of neoplasms, when irradiation of the washed blood product is not possible, the use of a leukocyte filter will provide a 1 log reduction of the tumour load.

### 5.8 Other indications

Autotransfusion may be contraindicated in subjects with haemoglobinopathies. In a case of a patient with Beta-thalassaemia requiring caesarean section which involved 9L of blood loss, increased haemolysis was noticed in the aspirated blood. This was counteracted by increasing the wash-volume. A sensor measuring the level of haemolysis in the effluent wash fluid was, in this case, a useful instrument (Waters et al. 2003).

Sickle cell disease (SCD) is an absolute contraindication due to erythrocyte haemolysis during hypoxic stress. Reinfusion of this blood caused serious coagulopathies (Fox et al. 1994).

Less absolute is autotransfusion in patients with the milder sickle cell trait. Storage of autologous blood has been described, without sickling (Romanoff 1988). Recently, in two case reports, sickling was displayed in 15-20% of the washed salvaged product, with subjects experiencing uneventful recovery (Okunuga & Skelton 2009). However, the proportion of HbS differs among the various carrier states (Hulatt & Fisher 2010). When applied, measurement of sickling in the collected blood prior to reinfusion is advisable.

## 6. Contraindications

### 6.1 Bacterial contamination

Not all authors consider bacterial contamination an absolute contraindication. It has been demonstrated that bacteria are not completely removed by centrifugation and washing (5-21% subsequently present) (Boudraux et al. 1983, Faught et al. 1998). As described in the trauma study (Bowley et al. 2006), in emergency cases, autotransfusion can be life-saving without causing harm to the patient. A few other case-reports confirm that prophylactic intravenous antibiotic therapy or addition of antibiotics to the anticoagulant solution could prevent bacteraemia or sepsis (Faught et al. 1998, Wollinsky et al. 1997).

### 6.2 Tumour surgery

Tumour surgery is considered an absolute contraindication to the use of autotransfusion due to fear of inducing metastases. Centrifugation and washing during processing of the aspirated blood does not remove all tumour cells and resulted in <1 log reduction in tumour load (Hanssen et al. 2002, 2004 (2x), 2006, Thomas MJG 1999, Stoffel et al. 2005). Tumour load in aspirated blood may be as high as  $10^7$  cells/litre (Hanssen 2002, 2006). The tumour cells remain viable and proliferate, as shown in in-vitro and animal models. Furthermore, leukocyte filtration can achieve just less than one more log reduction (Hanssen et al. 2004 (2x), 2006, Thomas MJG 1999). Radiation of the aspirated blood with 50 Gy resulted in a 10 log reduction in tumour load, after which no DNA-metabolism could be found (Thomas MJG 1999, Hanssen et al. 2002). There are special bags on the market for irradiation. The duration of the procedure is 6-15 minutes and is a complicated logistic process. However, combination of leukocyte filtration with irradiation has been found to remove all active tumour cells (Poli et al. 2008). Detailed studies showed that irradiation does not damage the red cells and that recovery in the first 24 hours is improved, presumed due to selective loss of senescent erythrocytes (Hanssen et al. 2002). Experience with transfusion of irradiated salvaged blood has been described in more than 700 patients without adverse effects (Valbonesi et al. 1999). Comparison of subject outcome with regard to differences between filtration or the irradiation techniques have not been published. Therefore, based on non-clinical studies, the irradiation technique is the only method that can be safely used.

A personal opinion is that in life-threatening bleeding during tumour surgery in the case of a Jehovah's Witness, reinfusion of autotransfused blood through a leukocyte filter may be considered.

### 6.3 Other contraindications

The following are described in guidelines, but not investigated in randomised studies: cleansing of the wound with toxic fluids; usage of haemostatic medicines on collagen or thrombin base; or aspiration of fat.

## 7. Haemovigilance

Risks of allogenic blood transfusions have been one of the motives for introduction of blood-saving techniques and employment of alternative methods. Years ago, haemovigilance was introduced to monitor the safety of allogenic blood transfusions. Currently, haemovigilance

for blood transfusion-saving techniques is not regulated. The Dutch foundation for haemovigilance (Transfusion Reactions In Patients: TRIP) has formulated a guideline comparable with that for allogenic blood transfusions, and begun with registration on a voluntary basis.

In 2004, a number of hospitals spontaneously reported incidents with autologous blood transfusion techniques (Zijlker et al. 2011). An annual increase in participation of other hospitals has been witnessed. The biggest hurdle is that registration of the total number of autotransfusions performed in Dutch hospitals (cell savers, drain blood reinfusion) in the Netherlands is not known, and a more complicated registration compared with allogenic blood transfusions which involve compulsory registration. In 2009, 2384 events were reported (2.9/1000 units of blood products), 98 of them were serious events (0.19%) including 3 involving autotransfusion techniques. In total, 35 incidents with cell savers or drain blood were reported ([www.tripnet.nl](http://www.tripnet.nl)). Momentarily, 18 hospitals not only report their adverse events, but also the total amount of procedures performed. Participation of other hospitals is encouraged by TRIP. More insight in risks may result in greater prevention in the future. In addition, long term outcome may be important as the study involving Aprotinin showed us (Mangano 2006, 2007, Karkouti 200). In summary, registration of long-term outcome should be encouraged for allogenic blood transfusions as well as for alternative techniques.

## 8. Conclusion

Perioperative autotransfusion started with reinfusion of unwashed shed blood intra- and postoperatively and soon appeared to be potentially dangerous (Koopman 1993). Results showed that blood collected intra-operatively was more dangerous than that collected postoperatively. This is explained by the damage caused by suction, high negative pressure, and contact with the air. Removal of the supernatant plasma and cell fragments by centrifugation and washing reduces side effects and the recovered product appeared safe for intra-operative use. Initially, infusion of unwashed drain blood was considered quite dangerous, but experience in recent years shows that despite the presence of potentially harmful substances, transfusion may be safe when used within certain limits. Such limits are: negative pressure not exceeding 100 mm Hg; reinfusion via a 40 micron filter; and a volume restriction of 15% of circulating volume with a maximum of 1500 ml for adults (this volume restriction is based on lack of randomised studies using larger volumes).

Provided all safety precautions are adhered to with regard to collection and apparatus used, there seems to be no volume restriction for the use of washed shed blood. Equipment with reliable optic sensors and a haemolysis controlling sensor are of import.

Several clinical and laboratory studies show that the quality of the saved erythrocytes (reflected in oxygen transport, osmotic fragility and survival) is equal to the circulating erythrocytes of the subjects, and better than stored autologous or allogeneic erythrocytes.

Massive blood loss can be managed by autotransfusion of recovered erythrocytes. Plasma and platelet concentrates, however, must be supplemented according to guidelines for massive blood loss.

With regard to all risks involved, and in comparison with allogeneic transfusion, a 50-60% decrease is witnessed with autotransfusion.

In the case of children, only specialised apparatus may be employed in washing techniques.

Disadvantages of autotransfusion in the case of tumour surgery or bacterially-contaminated surgical fields may be less than originally feared. In the context of a low degree of contamination, antibiotic prophylaxis may be adequate. Aspirated tumour cells are not sufficiently removed by filtration and washing. Currently, only irradiation of the recovered washed blood with 50 Gy has shown to give an adequate (10 log) reduction of tumour load. This requires, however, additional time, transport, validation of the irradiation process, labelling, and identification. This all adds to the costs of an irradiated unit. Filtration of the blood by means of a leukocyte depletion filter, taking 15 to 40 minutes, gives only a 2-3 log reduction of tumour load, and is therefore considered unsafe for employment in cancer surgery. However, in emergency cases or for Jehovah's Witnesses, it may be in certain circumstances an option to discuss with the patient. With an eye on the future, it is worthwhile to investigate if more simplistic methods of tumour cell reduction can be developed.

Blood saving techniques also have their side effects and incidents. At the moment haemovigilance of these incidents is not regulated. The Dutch experiences however highlight the importance of registration of these incidents comparable with those of allogeneic blood products.

## 9. References

- Allam, J., Cox, M., Jentis, S.M.. (2008) Cell salvage in obstetrics. *Internal Journal Obstetrics* Vol. 17: 37-45.
- Amin, A., Watson, A., Mangwani, J., Nawabi, D., Ahluwalia, R. & Loeffler, M. (2008) A prospective randomised controlled trial of autologous retransfusion in total knee replacement. *Journal of Bone Joint Surgery*. Vol. 90(4):451-454. ISSN: 0021-9355
- Blundell, J. (1818) Experiences on the transfusion of blood by syringe. *Medical Chirurgical Transfusion* Vol. 9: 56-92.
- Boodhwani, M., Nathan, H.J., Mesana, T.G. & Rubens, F.D. (2008) Cardiectomy Investigators. Effects of shed mediastinal blood on cardiovascular and pulmonary function: a randomized, doubleblind study. *Annals Thoracic Surgery*. Vol. 86(4):1167-1173. ISSN 0003-4975
- Boudreaux, J.P., Bornside, G.H. & Cohn, I. jr. (1983) Emergency autotransfusion: partial cleansing of bacteria-laden blood by cell washing. *J Trauma* Vol.23: 31-35. ISSN: 0022-5282
- Bowley, D.M., Barker, P. & Boffard, K.D. (2006) Intraoperative blood salvage in penetrating abdominal trauma: a randomised, controlled trial. *World Journal Surgery*. Vol. 30(6):1074-1080. ISSN: 0364-2313
- Brainard, D.M.D.. (1860) Amputation of the thigh for diseases of the knee joint. Transfusion of blood. *Chirurgical Medical Journal*. Vol. 18: 116-117.
- Bull, B.S. & Bull, M.H. (1990) The salvaged blood syndrome: a sequel to mechanochemical activation of platelets and leukocytes? *Blood Cells*. Vol. 16(1):5-20; discussion 20-23. ISSN 0340-4684
- Carless, P.A., Henry, D.A., Moxey, A.J., O'Connell, D.L. & Fergusson, D.A. Cell salvage for minimising perioperative allogeneic blood transfusion. *The Cochrane Database*

- of *Systematic Reviews* 2010, Issue 4. Art. No.: CD001888. DOI: 10.1002/14651858.CD001888.pub4
- Carrier, M., Denault, A., Lavoie, J. & Perrault, L.P. (2006) Randomized controlled trial of pericardial blood processing with a cell-saving device on neurologic markers in elderly patients undergoing coronary artery bypass graft surgery. *Annals Thoracic Surgery*. Vol. 82(1):51-55. ISSN 003-4975
- Dalén, T., Broström, L., & Gunnar-Enström, K. (1995) Cell Quality of salvaged blood after total knee arthroplasty. *Acta Orthopædica Scandinavica*. Vol. 66 (3): 329-333. ISSN 0001-6470
- Dalén, T., Broström, L., & Gunnar-Enström, K. (1997) Autotransfusion after total knee arthroplasty. Effects on blood cells, plasma chemistry, and whole blood rheology. *Journal of Arthroplasty*. Vol. 12 (5): 517-525. ISSN 083-5403
- Dalén, T. & Engström, K.G. (1998) Filterability of autotransfusion Blood Cells and plasma after total knee arthroplasty. *Clinical Hemorheology Microcirculation* Vol. 19:181-195. ISSN 1386-0291
- Dalén, T. & Engström, K.G. (1999) Microrheology of filtered autotransfusion drain blood with and without leukocyte reduction. *Clinical Hemorheology Microcirculation*. Vol. 21:113-123. ISSN 1386-0291
- Davis, M., Sofer, M., Gomez-Marin, O., Bruck, D. & Soloway, M.S.(2003) The use of cell salvage during radical retropubic prostatectomy: does it influence cancer recurrence? *British Journal Urology International* . Vol. 91(6):474-476. ISSN: 1464-4096
- Djaiani, G., Fedorko, L., Borger, M.A., Green, R., Carroll, J., Marcon, M. & Karski, J. (2007) Continuous-flow cell saver reduces cognitive decline in elderly patients after coronary bypass surgery. *Circulation*. Vol. 23;116(17):1888-1895. ISSN: 0009-7322
- Faught, C., Wells, P., Fergusson, D. & Laupacis, A. (1998) Adverse effects of methods for minimizing perioperative allogenic transfusion: a critical review of the literature. *Transfusion Medicine Review*. Vol. 12:206-225. ISSN 0887-7963
- Ferraris, V.A. et al. (2007) for the working force of the society of thoracic surgeons and the society of cardiovascular anesthesiologists clinical practice guideline: Perioperative blood transfusion and blood conservation in cardiac surgery: *Annals Thoracic Surgery*. Vol. 83: S27-86. ISSN 003-4975
- Ford, B.S., Sharma, S., Rezaishiraz, H., Huben, R.S. & Mohler, J.L. (2008). Effect of perioperative blood transfusion on prostate cancer recurrence. *Urology Oncology*. Vol. 26(4):364-367. ISSN 1078-1439
- Fox, J.S., Amalanath, L., Hoeltge, G.A., Andrish, J.T.. (1994) Autologous blood transfusion and intraoperative salvaged in a patient with homozygous sickle cell disease. *Cleveland Clinical Journal Medicine* vol 61: 137-40.
- Gallina, A., Briganti, A., Chun, F.K., Walz, J., Hutterer, G.C., Erbersdobler, A., Eichelberg, C., Schlomm, T., Ahyai, S.A., Perrotte, P., Saad, F., Montorsi, F., Huland, H., Graefen, M. & Karakiewicz, P.I. (2007) Effect of autologous blood transfusion on the rate of biochemical recurrence after radical prostatectomy. *British Journal Urology International*. Vol. 100(6):1249-1253. ISSN: 1464-4096
- Gharehbaghian, A., Haque, K.M., Truman, C., Evans, R., Morse, R., Newman, J., Bannister, G., Rogers, C. & Bradley, B.A. (2004) Effect of autologous salvaged blood on



- postoperative natural killer cell precursor frequency. *Lancet*. Vol. 363(9414):1025-1030. ISSN: 0140-6736
- Giordano, G.F., Giordano, D.M., Wallace, B.A., Giordano, K.M., Prust, R.S. & Sandler, S.G. (1993) An analysis of 9,918 consecutive perioperative autotransfusion. *Surgical Gynecology Obstetrics* Vol. 176(2):103-110. ISSN 0039-6087
- Handel, M., Boluki, D., Loibl, O., Schaumburger, J., Kalteis, T., Matussek, J. & Grifka, J. (2006) Postoperative autologous retransfusion of collected shed blood after total knee arthroplasty with the cell saver. *Zeitschrift Orthopädie und Ihre Grenzgebiet*. Vol. 144(1):97-101. ISSN 0044-3220
- Hansen, E., Bechmann, V. & Altmeppen, J. (2002) Intraoperative blood salvage in cancer surgery: safe and effective? *Transfusion Apheresis Science*. Vol. 27(2):153-157. ISSN 1473-0502
- Hansen, E., Bechmann, V., Altmeppen, J., Wille, J. & Roth, G. (2004). Quality assurance in blood salvage and variables affecting quality. *Anesthesiol Intensivmed Notfallmed Schmerzther*. Vol. 39(9):569-575. ISSN 0939-2661
- Hansen, E., Pawlik, M., Altmeppen, J., Bechmann, V. (2004). Autologous transfusion -- from euphoria to reason: clinical practice based on scientific knowledge (Part II). Intraoperative blood salvage with blood irradiation -- from an anaesthesiological point of view. *Anesthesiol Intensivmed Notfallmed Schmerzther*. Vol. 39(11):676-682. ISSN 0939-2661
- Hansen, E. (2006). Failed evidence of tumour cell removal from salvaged blood after leucocyte depletion. *Transfusion Medicine*. Vol. 16(3):213-4; author reply 215-216. ISSN 0958-7578
- Hendrych, J. (2006). Use of post-operative drainage and auto-transfusion sets in total knee arthroplasty. *Acta Chir Orthop Traumatol Cech*. Vol. 73(1):34-38. ISSN 0001-5415
- Horstmann, W.G., Slappendel, R., Hellemond van, G.G., Castelein, R.M. & Verheyne, C.C.P.M. (2009). Safety of retransfusion of filtered shed to minimize blood in 1819 patients after total hip or knee arthroplasty. *Transfusion Alternatives in Transfusion Medicine*. Vol. 10: 174-181. ISSN 1295-9022
- Hüet, C., Salmi, L.R., Fergusson, D., Koopman-van Gemert, A.W.M.M., Rubens, F. & Laupacis, A., ISPO investigators. (1999). A meta-analysis of the effectiveness of cell salvage perioperative allogenic blood transfusion in cardiac and orthopedic surgery. *Anesthesia Analgesia*. Vol. 89:861-869. ISSN 0003-2999
- Hulatt, L.J. & Fisher. (2010) H. Intra-operative cell salvage and sickle cell carrier state. *Anaesthesia*. Vol. 65: 649. ISSN: 0003-2409
- Jensen, C.M., Pilegaard, R., Hviid, K., Nielsen, J.D. & Nielsen, H.J. (1999). Quality of reinfused drainage blood after total knee arthroplasty. *Journal of Arthroplasty*. Vol. 14(3):312-318. ISSN 0883-5403
- Jones, H.W., Savage, L., White, C., Goddard, R., Lumley, H., Kashif, F. & Gurusany, K. (2004). Postoperative autologous blood salvage drains--are they useful in primary uncemented hip and knee arthroplasty? A prospective study of 186 cases. *Acta Orthopædica Belgica*. Vol. 70(5):466-473. ISSN 0001-6462
- Jong de, M., Ray, M., Crawford, S., Whitehouse, S.L. & Crawford, R.W. (2007). Platelet and leukocyte activation in salvaged blood and the effect of its reinfusion on the circulating blood. *Clinical Orthopaedics and Related Research*. Vol. 456:238-242. ISSN 0009-921X

- Karkouti, K., Beattie, W.S., Dattilo, K.M., McCluskey, S.A., Ghannam, M. & Hamdy, A. (2006). A propensity score case-control comparison of aprotinin and tranexamic acid in high transfusion-risk cardiac surgery. *Transfusion*. Vol. 46: 327-338. ISSN: 0041-1132
- Kent, P., Ashley, S., Thorley, P.J., Shaw, A., Parkin, A. & Kester, R.C. (1991). 24-hour survival of autotransfused red cells in elective aortic surgery: a comparison of two intraoperative autotransfusion systems. *British Journal Surgery*. Vol. 78:1473-1475. ISSN: 0007-1323
- Kirkos, J.M., Krystallis, C.T., Konstantinidis, P.A., Papavasiliou, K.A., Kyrkos, M.J. & Ikonomidis, L.G. (2006). Postoperative re-perfusion of drained blood in patients undergoing total knee arthroplasty: is it effective and cost-efficient? *Acta Orthopædica Belgica*. Vol. 72(1):18-23. ISSN 0001-6462
- Klein, A.A., Nashef, S.A., Sharples, L., Bottrill, F., Dyer, M., Armstrong, J. & Vuylsteke, A. (2008). A randomized controlled trial of cell salvage in routine cardiac surgery. *Anesthesia Analgesia*. Vol. 107(5):1487-1495. ISSN 0003-2999
- Koopman-van Gemert, A.W.M.M. (1993) Peri-operative autotransfusion by means of a blood cell separator [2e edition]. Publisher: J.J.H.M. van Gemert & J.J.R.M. van Gemert uitgeverij De Alk, ISBN 90-9005755-2, Alkmaar
- Krohn, C.D., Reikerås, O., Bjørnsen, S. & Brosstad, F. (2001). Fibrinolytic activity and postoperative salvaged untreated blood for autologous transfusion in major orthopaedic surgery. *European Journal Surgery*. Vol. 67(3):168-172. ISSN 1753-1934
- Mangano, D.T., Tudor, I.C. & Dietzel, C. (2006). Multicenter Study of Perioperative Ischemia Research Group; Ischemia Research and Education Foundation. The risk associated with aprotinin in cardiac surgery. *New England Journal of Medicine*. Vol. 26;354(4):353-365. ISSN: 0028-4793
- Mangano, D.T., Miao, Y., Vuylsteke, A., Tudor, I.C., Juneja, R. & Filipescu, D. (2007). Investigators of The Multicenter Study of Perioperative Ischemia Research Group; Ischemia Research and Education Foundation. Mortality associated with aprotinin during 5 years following coronary artery bypass graft surgery. *Journal of the American Medical Association*. Vol. 7;297(5):471-479. ISSN: 0098-7484
- Marcheix, B., Carrier, M., Martel, C., Cossette, M., Pellerin, M., Bouchard, D. & Perrault, L.P. (2008). Effect of pericardial blood processing on postoperative inflammation and the complement pathways. *Annals Thoracic Surgery*. Vol. 85(2):530-535. ISSN 003-4975
- Marcus, C.S., Myhre, A., Angulo, M.C., Salk, R.D., Essex, C.E. & Demianew, S.H. (1987). Radiolabeled red cell viability. Comparison of <sup>51</sup>Cr, <sup>99m</sup>Tc and <sup>111</sup>In for measuring the viability of autologous stored red cells. *Transfusion*. Vol. 27: 315-319. ISSN: 0041-1132
- McInroy, A. (2005). Blood transfusion and Jehovah's Witnesses: the legal and ethical issues. *British Journal of Nursing*. Vol. 14(5):270-274. ISSN 0966-0461
- McShane, A.J., Power, C., Jackson, J.F., Murphy, D.F., MacDonald, A., Moriarty, D.C. & Otridge, B.W. (1987). Autotransfusion: quality of blood prepared with a red cell processing device. *British Journal Anaesthesia*. Vol. 59: 1035-1039. ISSN 0007-0912
- Moonen, A.F., Knoors, N.T., Os van, J.J., Verburg, A.D. & Pilot P. (2007). Retransfusion of filtered shed blood in primary total hip and knee arthroplasty: a prospective randomized clinical trial. *Transfusion*. Vol. 47(3):379-384. ISSN: 0041-1132

- Muñoz, M., Slappendel, R. & Thomas, D. (2011). Laboratory characteristics and clinical utility of post-operative cell salvage: washed or unwashed Blood Transfus? *Blood Transfusion*. Vol. 9(3):248-261. ISSN: 1723-2007
- Nieder, A.M., Simon, M.A., Kim, S.S., Manoharan, M. & Soloway, M.S. (2004). Intraoperative cell salvage during radical prostatectomy: a safe technique for Jehovah's Witnesses. *International Brazilian Journal Urology*. Vol. 30(5):377-379. ISSN 1677-5538
- Nieder, A.M., Manoharan, M., Yang, Y. & Soloway, M.S. (2007). Intraoperative cell salvage during radical cystectomy does not affect long-term survival. *Urology*. Vol. 69(5):881-884. ISSN: 0090-4295
- Okunuga, A. & Kleton, V.A. (2009). Use of cell salvage in patients with sickle cell trait. *International Journal Obstetric Anesthesia*. Vol. 18 (1): 90-91. ISSN 0959-289X
- Pleym, H., Tjomsland, O., Asberg, A., Lydersen, S., Wahba, A., Bjella, L., Dale, O. & Stenseth, R. (2005). Effects of autotransfusion of mediastinal shed blood on biochemical markers of myocardial damage in coronary surgery. *Acta Anaesthesiologica Scandinavica*. Vol. 49(9):1248-1254. ISSN 0001-5172
- Poli, M., Camargo, A., Villa, L., Moura, R., Colella, R. & Deheinzelin, D. (2008). Intraoperative autologous blood recovery in prostate cancer surgery: in vivo validation using a tumour marker. *Vox Sanguinis*. Vol. 95(4):308-312. ISSN: 0042-9007
- Ramírez, G., Romero, A., García-Vallejo, J.J. & Muñoz, M. (2002). Detection and removal of fat particles from postoperative salvaged blood in orthopedic surgery. *Transfusion*. Vol. 42(1):66-75. ISSN: 0041-1132
- Reijngoud, L.W.P., Pattyn, C., De Haan, R., De Somer, F., Campbell, P.A., Harinderjit, S., Gil, H.S. & De Smet, K.A. (2009). Does Intraoperative Cell Salvage Remove Cobalt and Chromium from Reinfused Blood? *Journal of Arthroplasty*. Vol. 24(7):1125-1129. ISSN 0883-5403
- Schmidt, H., Bendtzen, K. & Mortensen, P.E. (1998). The inflammatory cytokine response after autotransfusion of shed mediastinal blood. *Acta Anaesthesiologica Scandinavica*. Vol. 42:558-564. ISSN 0001-5172
- Schmidt, H., Lund, J.O. & Steen, L.N. (1996). Autotransfused shed mediastinal blood has normal erythrocyte survival. *Annals Thoracic Surgery*. Vol. 62: 105-108. ISSN 003-4975
- Schönberger, J.P., Everts, P.A., Bredee, J.J., Jansen, E., Goedkoop, R. & Bavinck, J.H. (1992). The effect of postoperative normovolaemic anaemia and autotransfusion on blood saving after internal mammary artery bypass surgery. *Perfusion*. Vol. 7:257-262. ISSN 0267-6591
- Schroeder, S., Spiegel von, T., Stuber, F., Hoeft, A., Preusse, C.J., Welz, A., Kampe, S. & Lier, H. (2007). Interleukin-6 enhancement after direct autologous retransfusion of shed thoracic blood does Not influence haemodynamic stability following coronary artery bypass grafting. *Thoracic Cardiovascular Surgery*. Vol. 55(2):68-72. ISSN 0022-5223
- Selo-Ojeme, D.O., Feyi-Waboso, P.A. (2007). Salvage autotransfusion versus homologous blood transfusion for ruptured ectopic pregnancy. *International Journal Gynaecology Obstetrics*. Vol. 96(2):108-111. ISSN 1470-0328
- Sinardi, D., Marino, A., Chillemi, S., Irrera, M., Labruto, G. & Mondello, E.. (2005). Composition of the blood sampled from surgical drainage after joint arthroplasty: quality of return. *Transfusion*. Vol. 45(2):202-207. ISSN: 0041-1132

- Sirvinskas, E., Veikutiene, A., Benetis, R., Grybauskas, P., Andrejaitiene, J., Veikutis, V. & Surkus, J. (2007). Influence of early re-infusion of autologous shed mediastinal blood on clinical outcome after cardiac surgery. *Perfusion*. Vol. 22(5):345-352. ISSN 0267-6591
- So-Osman, C., Nelissen, R.G., Eikenboom, H.C. & Brand, A. (2006). Efficacy, safety and user-friendliness of two devices for postoperative autologous shed red blood cell re-infusion in elective orthopaedic surgery patients: A randomized pilot study. *Transfusion Medicine*. Vol. 16(5):321-328. ISSN 0958-7578
- So-Osman, C., Nelissen, R.G.H.H., Koopman-van Gemert, A.W.M.M., Kluyver, E., Pöll, R., Onstenk, R.,
- Van Hilten, J.A., Jansen-Werkhoven, T.M., Brand, R. & Brand A. (2011). A randomised controlled trial on erythropoietin and blood salvage as transfusion alternative in orthopedic surgery using a restrictive transfusion policy. *Transfusion Alternatives in Transfusion Medicine*. Vol. 12 (1): 25. ISSN 1295-9022
- Smith, L.K., Williams, D.H. & Langkamer, V.G.(2007). Post-operative blood salvage with autologous retransfusion in primary total hip replacement. *Journal Bone Joint Surgery British*. Vol.89(8):1092-7. ISSN: 0301-620X
- Stoffel, J.T., Topjian, L. & Libertino, J.A. (2005). Analysis of peripheral blood for prostate cells after autologous transfusion given during radical prostatectomy. *British Journal Urology International*. Vol. 96(3):313-315. ISSN: 1464-4096
- Stachura, A., Król, R., Poplawski, T., Michalik, D., Pomianowski, S., Jacobsson, M., Åberg, M. & Bengtsson, A. (2010). Transfusion of intra-operative autologous whole blood: influence on complement activation and interleukin formation. *Vox Sanguinis*. Vol. 2; 239-246. ISSN: 0042-9007
- Svenmarker, S., Engström, K.G., Karlsson, T., Jansson, E., Lindholm, R. & Åberg, T. (2004). Influence of pericardial suction blood retransfusion on memory function and release of protein S100B. *Perfusion*. Vol. 19(6):337-343. ISSN 0267-6591
- Takagi, H., Sekino, S., Kato, T., Matsuno, Y. & Umemoto, T. (2007). Intraoperative autotransfusion in abdominal aortic aneurysm surgery: meta-analysis of randomized controlled trials. *Archives Surgery*. Vol. 142(11):1098-1101. ISSN 0096-6908
- Tawes, R.L. Jr. & Duvall, T.B. (1996). Is the "salvaged-cell syndrome" myth or reality? *American Journal Surgery*. Vol. 172 (2):172-174. ISSN: 0002-9610
- Thomas, D. (2005). Facilities for blood salvage (cell saver technique) must be available in every obstetric theatre. *International Journal Obstetric Anesthesia*. Vol. 14(1):48-50. ISSN 0959-289X
- Thomas, M.J.G. (1999). Infected and malignant fields are an absolute contraindication to intraoperative cell salvage: fact or fiction? *Transfusion Medicine*. Vol. 9:269-278. ISSN 0958-7578
- Thorley, P.J., Shaw, A., Kent, P., Ashley, S., Parkin, A. & Kester, R.C. (1990). Dual tracer technique to measure salvaged red cell survival following autotransfusion in aortic surgery. *Nuclear Medicine Communication*. Vol. 11:369-374. ISSN 0143-3636
- Tripković, B., Buković, D., Sakić, K., Sakić, S., Buković, N. & Radaković, B. (2008). Quality of the blood sampled from surgical drainage after total hip arthroplasty. *Collegium Antropologicum*. Vol. 32(1):153-160. ISSN 0350-6134
- Tsumara, N., Yoshiya, S., Chin, T., Shiba, R., Kohso, K. & Doita, M. (2006). A prospective comparison of clamping the drain or post-operative salvage of blood in reducing



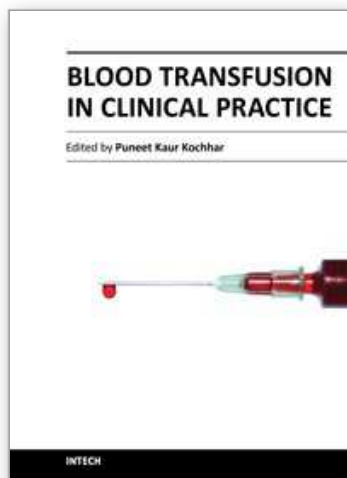
- blood loss after total knee arthroplasty. *Journal Bone Joint Surgery British*. Vol. 88(1):49-53. ISSN: 0301-620X
- Tylman, M., Bengtson, J.P., Avall, A., Hyllner, M. & Bengtsson, A. (2001). Release of interleukin-10 by reinfusion of salvaged blood after knee arthroplasty. *Intensive Care Medicine*. Vol. 27(8):1379-84. ISSN 0342-4642
- Van Wolfswinkel, M.E.. (2009). Maternal mortality and serious maternal morbidity in Jehovah's Witnesses in the Netherlands. *British Journal Obstetrics Gynaecology*. Vol. 116: 1103-1110. ISSN: 1470-0328
- Valbonesi, M., Bruni, R., Lercari, G., Florio, G., Carlier, P. & Morelli, F. (1999). Autoapheresis and intraoperative blood salvage in oncologic surgery. *Transfusion Science*. Vol. 21:129-139. ISSN 0955-3886
- Vries de, A.J., Gu, Y.J., Post, W.J., Vos, P., Stokroos, I., Lip, H. & Oeveren van, W. (2003). Leucocyte depletion during cardiac surgery: a comparison of different filtration strategies. *Perfusion*. Vol. 18(1):31-38. ISSN 0267-6591
- Vries de, A.J., Vermeijden, W.J., Gu, Y.J., Hagenaars, J.A. & Oeveren van, W. (2006). Clinical efficacy and biocompatibility of three different leukocyte and fat removal filters during cardiac surgery. *Artificial Organs*. Vol. 30(6):452-457. ISSN 0160-564X
- Waters, J.H., ShinJung Lee, J., Klein, E., O'Hara, J., Zippe, C. & Potter, P.S . (2004). Preoperative Autologous Donation Versus Cell Salvage in the Avoidance of Allogeneic Transfusion in Patients Undergoing Radical Retropubic Prostatectomy. *Anesthesia Analgesia*. Vol. 98:537-542. ISSN 0003-2999
- Westerberg, M., Gäbel, J., Bengtsson, A., Sellgren, J., Eidem, O. & Jeppsson, A. (2006). Hemodynamic effects of cardiotomy suction blood. *Journal Thoracic Cardiovascular Surgery*. Vol. 131(6):1352-1357. ISSN 0022-5223
- Wiefferink, A., Weerwind, P.W., Heerde van, W., Teerenstra, S., Noyez, L., Pauw de, B.E. & Brouwer, R.M. (2007). Autotransfusion management during and after cardiopulmonary bypass alters fibrin Degradation and transfusion requirements. *Journal Extra Corporeal Technology*. Vol. 39(2):66-70. ISSN 0022-1058
- Wixson, R.L., Kwaan, H.C/\., Spies, S.M. & Zimmer, A.M. (1994). Reinfusion of postoperative wound drainage in total joint arthroplasty: Red blood cell survival and coagulopathy risk. *Journal Arthroplasty* Vol. 9:351-357. ISSN 0883-5403
- Wollinsky, K.H., Oethinger, M., Buchele, M., Kluger, P. & Puhl, W., Hinrich-Mehrken H. (1997). Autotransfusion bacterial contamination during hip arthroplasty and efficacy of cefurocime prophylaxis: a randomized controlled study of 40 patients. *Acta Orthopædica Scandinavica*. Vol. 68:225-230. ISSN 0001-6470
- Wong, J.C.L., Torella, F., Haynes, S.L., Dalrymple, K., Mortimer, A.J. & McCollum, C.N., ATIS Investigators.(2002). Autologous versus allogenic transfusion in aortic surgery. *Annals Surgery* Vol. 235:145-151. ISSN: 0003-4932
- Wood, G.C., Kapoor, A. & Javed, A. (2008). Autologous drains in arthroplasty a randomized control trial. *Journal of Arthroplasty*. Vol. 23(6):808-813. ISSN 0883-5403
- Woolley, S. (2005). Jehovah's Witnesses in the emergency department: what are their rights? *Emergency Medicine Journal*. Vol. 22(12):869-71. ISSN: 1472-0205
- Zacharopoulos, A., Apostolopoulos, A. & Kyriakidis, A . (2007). The effectiveness of reinfusion after total knee replacement. A prospective randomised controlled study. *International orthopaedics*. Vol. 31(3):303-308. ISSN 0341-2695.



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