Cell salvage intraoperatively and postoperatively – worth a go?

Dafydd Thomas

Consultant in ICM

DIrector of Cardiac ITU

Chair SHOT Steering Group

Welsh Blood Service

Immediate Past Chair NATA

Past President BBTS

GIG CYMRU NHS WALES
Bwrdd Iechyd Prifysgol Abertawe Bro Morgannwg University Health Board

Gwasanaeth Gwaed Cymru

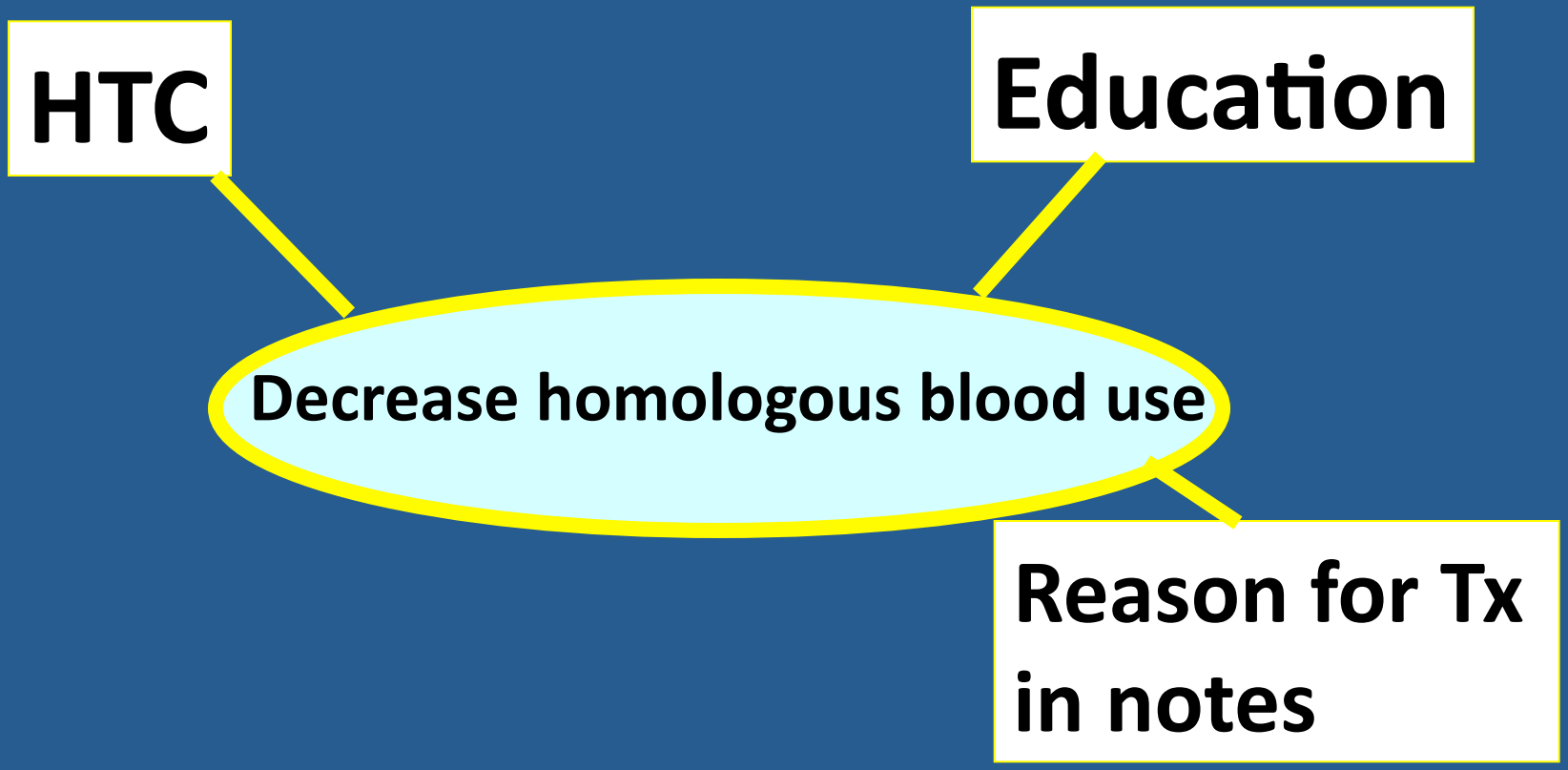
nata
Network for Advancement of Transfusion Alternatives

GIG CYMRU NHS WALES
Gwasanaeth Gwybodeg Informatics Service

Some common questions Still safe and effective?

- Is it safe?
- It makes patients bleed
- It is too expensive
- It increases infection
- It is not cost-effective
- Is it safe to use it in Obstetrics, Malignancy, Infection?

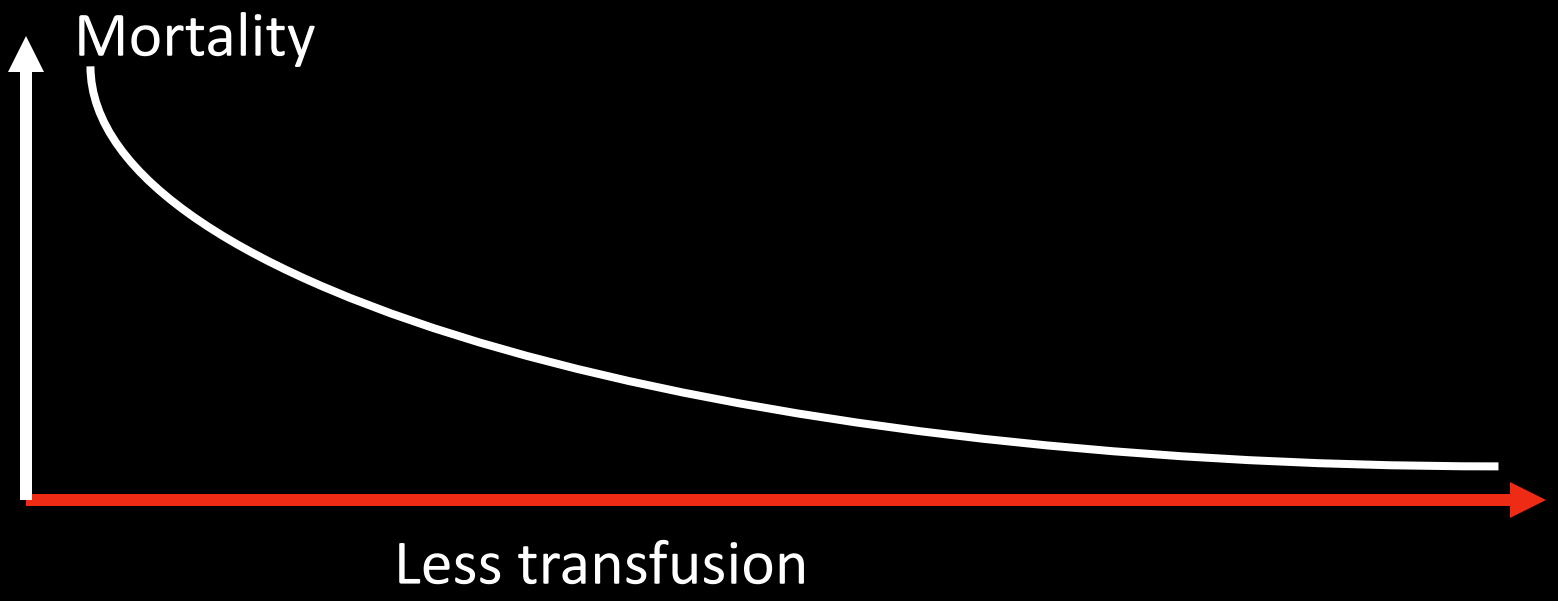
Blood Conservation



1993

Transfusion effect ? How can we separate from surgical effect ?

Massive Haemorrhage Complicated or Unexpected Difficult surgery	Withhold transfusion Complicated surgery Moderate or controlled haemorrhage	Minimal Haemorrhage Straightforward Surgery



Blood Conservation

Pre-op preparation

Education

Decrease homologous blood use

Electronic X match

Reason for Tx in notes

Cell Salvage

1993

The best transfusion is the one the patient avoids

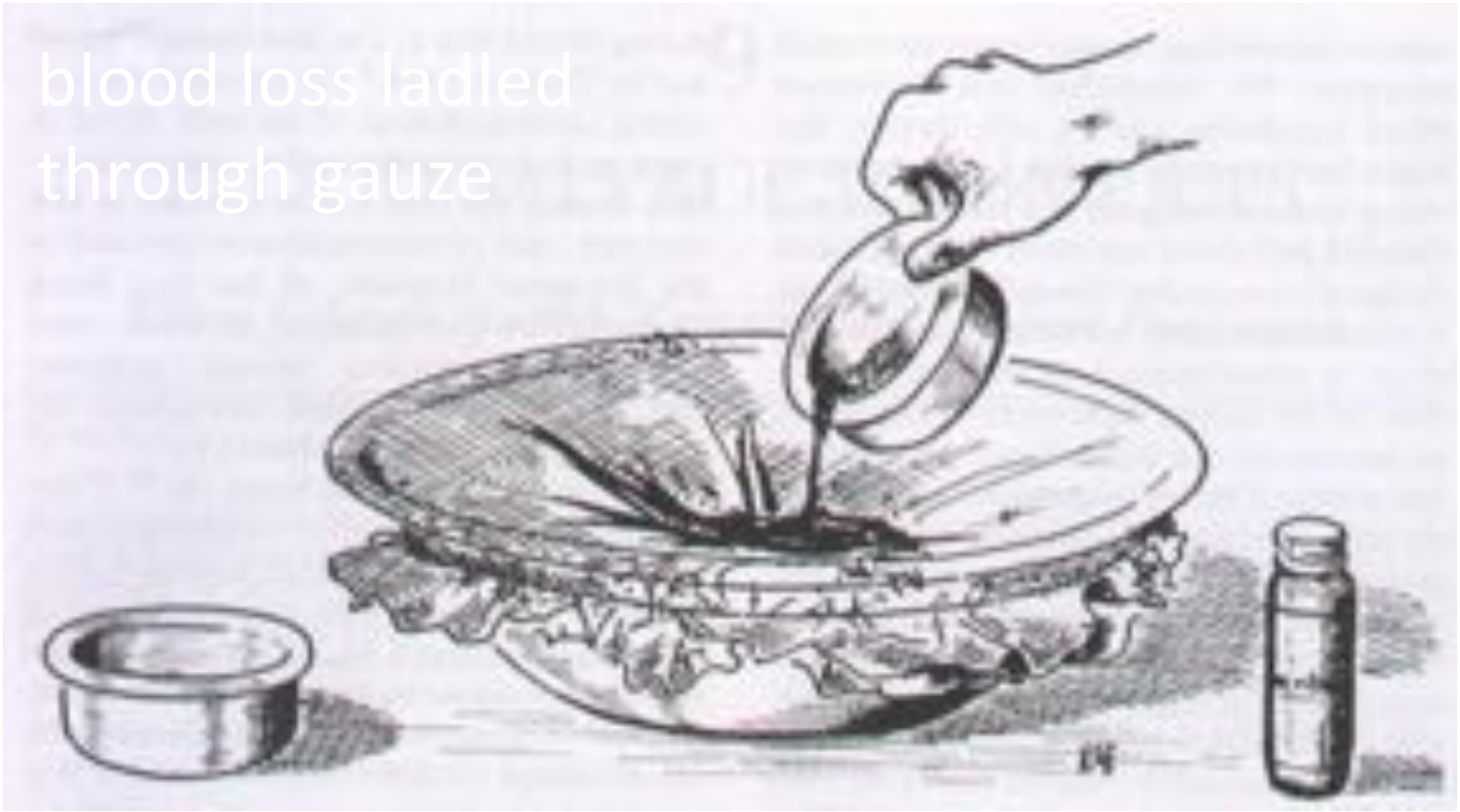
The next best is the patients own fresh blood

History of Cell Salvage Autotransfusion

• Blundell	1818
• Duncan	1886
• Theis	1914
• Elmendorf	World War 1
• Cook County Hospital,	WW2
• Vietnam	Late 1960’s

Subsequent early pioneers:

- Van Schailk HD. *Penetrating wounds of the abdomen*. J Florida Med Assoc **1927**; 14; 33-34
- Tiber LJ. California West M., **1934**, 41: 16-20 *(189 ectopics)*



History of Cell Salvage Autotransfusion

- Gibbons 1953
- Dyer and Rob 1966
- Klebenoff 1967
- Bentley ATS 100 1968
- Taswell and Wilson 1968
- Latham 1970's

Intra-operative red cell salvage

- High collection/transfusion ratio
- Fresh blood
- ? Revenue neutral

Red Cell Salvage

-Accelerated sedimentation
  5,500 revs.
-Centrifugal device
-Wash cycle
-Volume 225 ml
-Hct 55-75
-Platelets 15,000

Properties of whole blood and red cell concentrates stored in CPDA

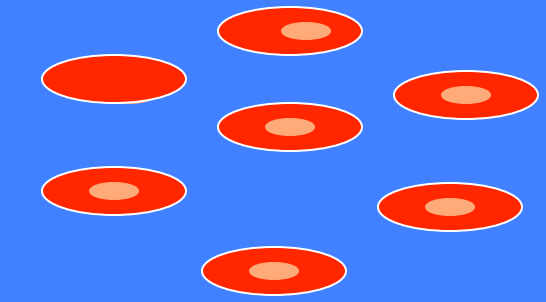
Parameter	Days of Storage			
	0	35(Whole Blood)	35(Packed Cells)	
pH	7.55	6.98	6.71	Alkaline
Plasma Haemoglobin(mg/dL)	8.2	46.1	246.0	80 -200
Plasma potassium(mEq/L)	4.2	27.3	76.0	Normal
Plasma sodium(mEq/L)	169	155	122	Normal
Blood dextrose(mg/dL)	440	229	84	
2,3,DPG (microM/ml)	13.2	<1	<1	Higher
Percent survival	-	79	71	70 -80

From: Miller/ Transfusion Therapy, Anaesthesia, 4th Edition

Autotransfusion: Quality of Blood Prepared with a Red Cell Washing Device

- Higher Hb concentration
- Higher 2,3-DPG
- Higher WCC
- Higher pH
- Physiological potassium concentration
- Heparin 0.64u.ml^{-1}
- Low platelets

Br J Anaesth (1987): 59: 1035-1039



Red Blood Cells

8μm in diameter

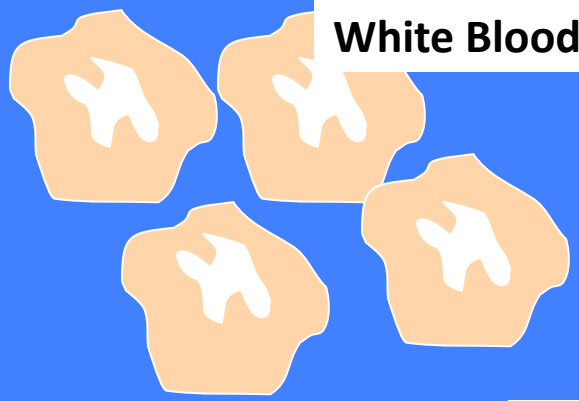
3 μm vessels

120 days and travels 300 miles

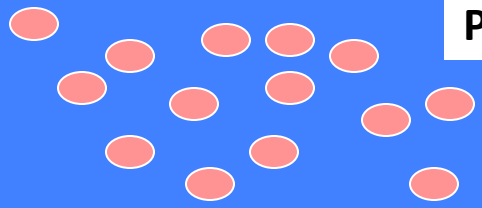
Flexible biconcave disc

Hb A MW 68,000

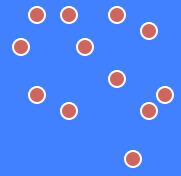
640 million haemoglobin molecules



White Blood Cells



Platelets



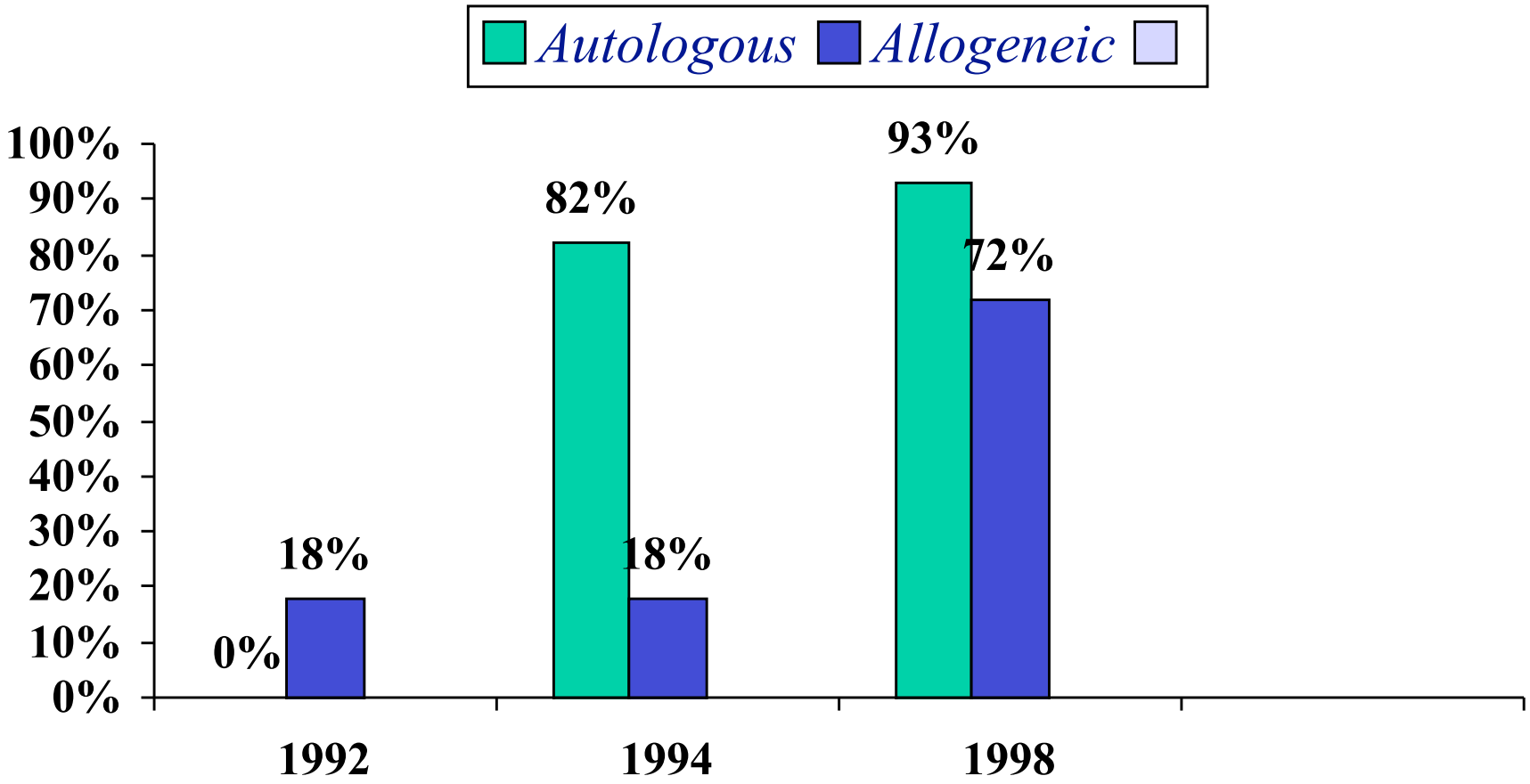
Bacteria

Heparin MW 15-18,000

Heparin, Betadine, Antibiotics

40 micron micro-aggregate filter

Avoidance of allogenic blood



Cell salvage for minimising perioperative allogeneic blood transfusion (Review)

Carless PA, Henry DA, Moxey AJ, O'Connell DL, Fergusson DA

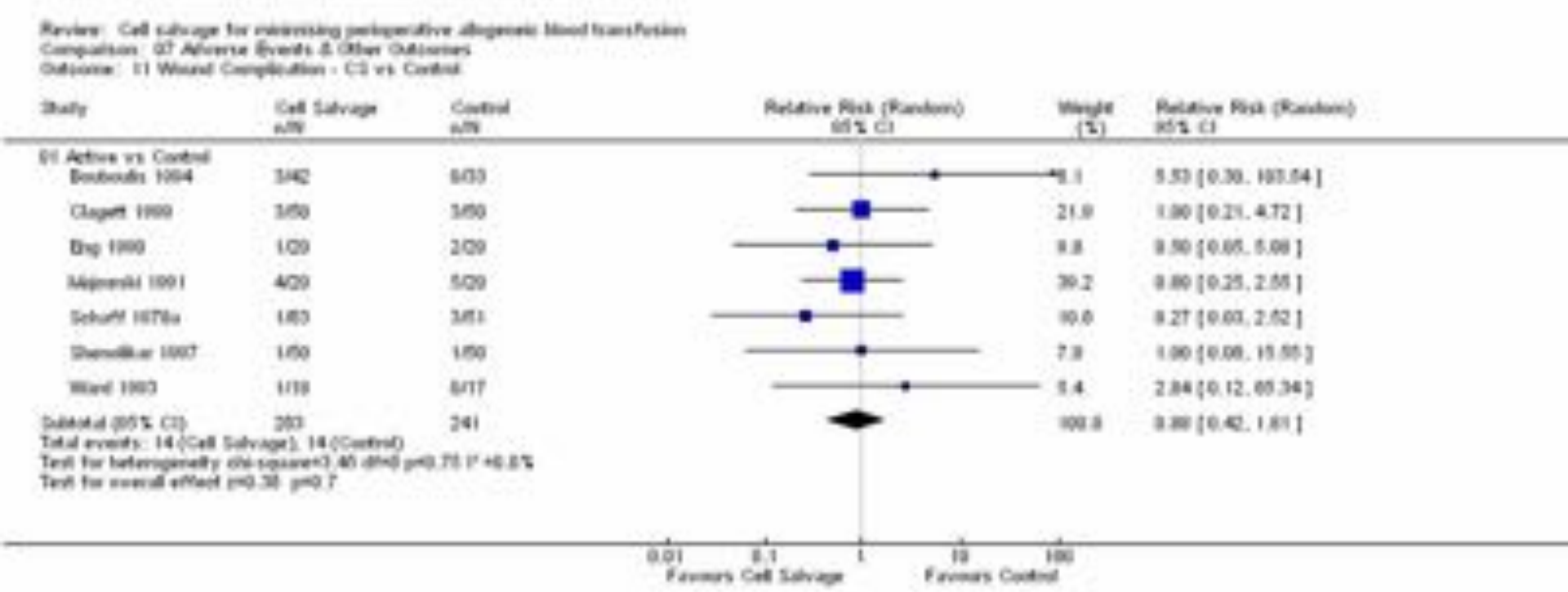
Comparison in term of efficacy: Meta-analysis on alternativesto allogeneic blood transfusion

PAD decreases the risk of allogeneic transfusion /5

Relative Risk

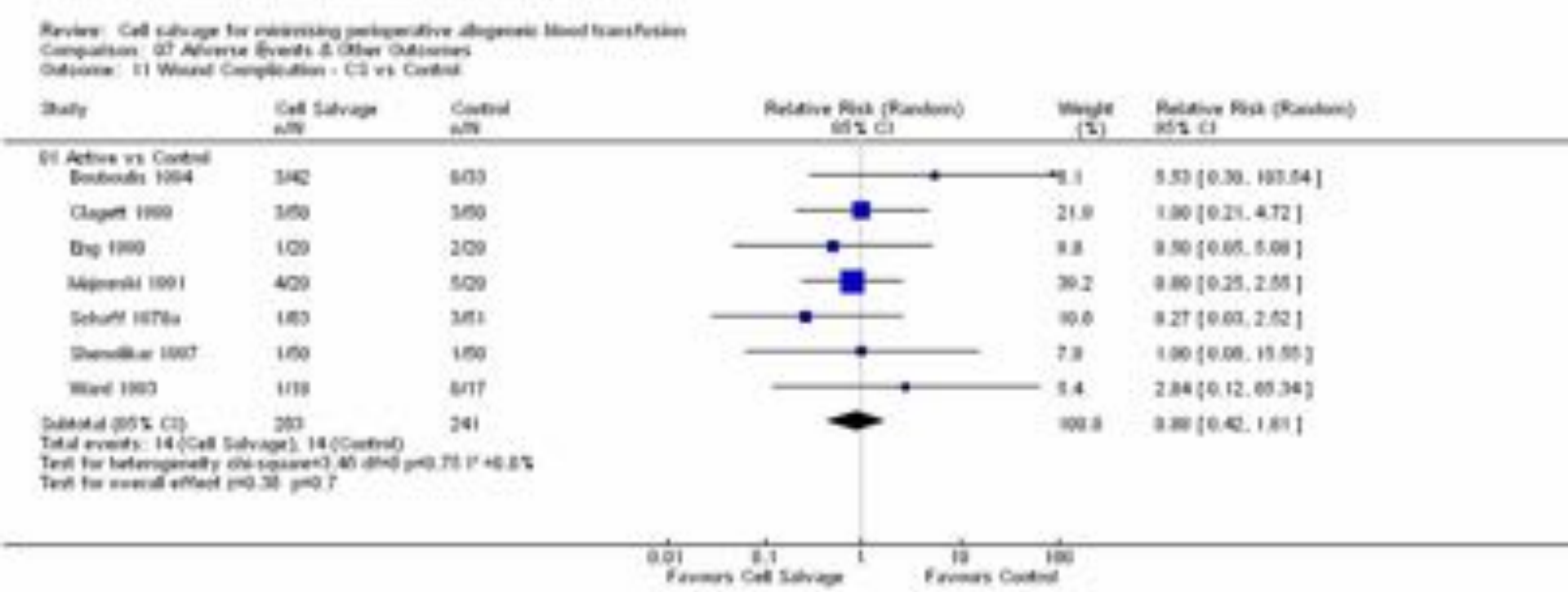
PAD	(Forgie 1998)		0.17 (0.08-032)
EPO	(Laupacis 1998)		0.36 (0.24-0.56)
Cell saving	(Huet 1999)	ow	0.39 (0.30-0.51)
Postop salvage	**(Huet 1999)**	ounw	0.35 (0.26-0.46)
ANH	**(Bryson 1997)**		0.64 (0.31-1.31)

Adverse Events & Other Outcomes, Outcome Any Infection - CS vs Control



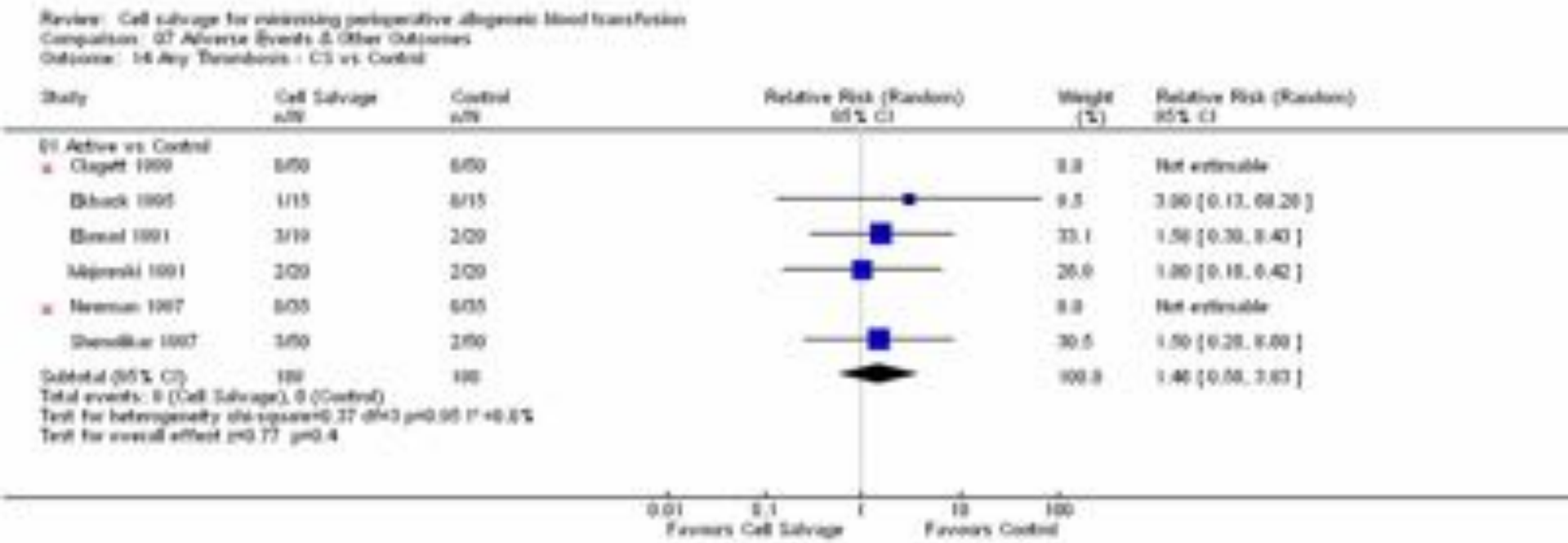
Carless: The Cochrane Library, Volume (1).2007.

Adverse Events & Other Outcomes, Outcome Wound Complication - CS vs Control



Carless: The Cochrane Library, Volume (1).2007.

Adverse Events & Other Outcomes, Outcome Any Thrombosis - CS vs Control



Carless: The Cochrane Library, Volume (1).2007.

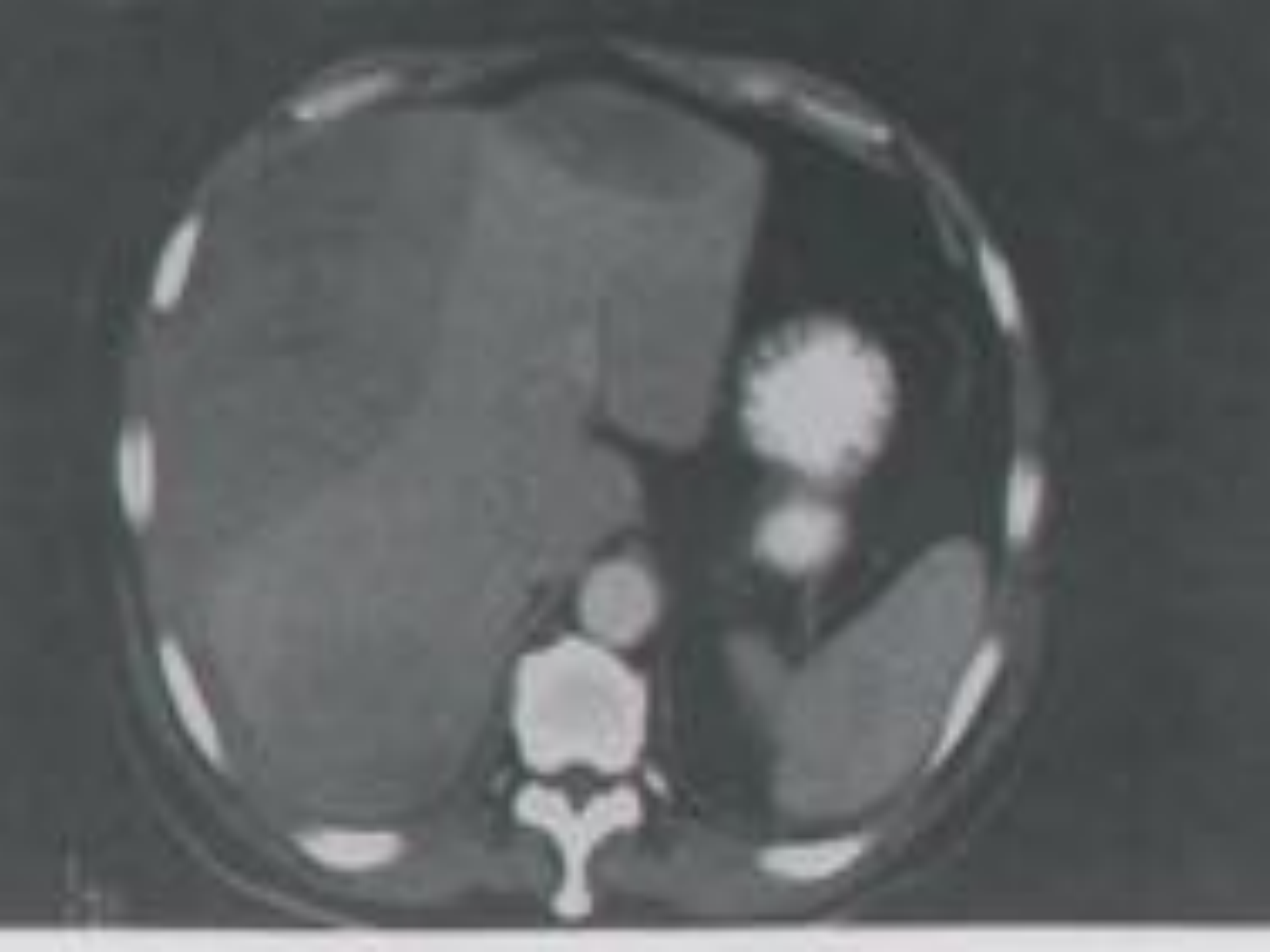
Restoration of blood volume

+

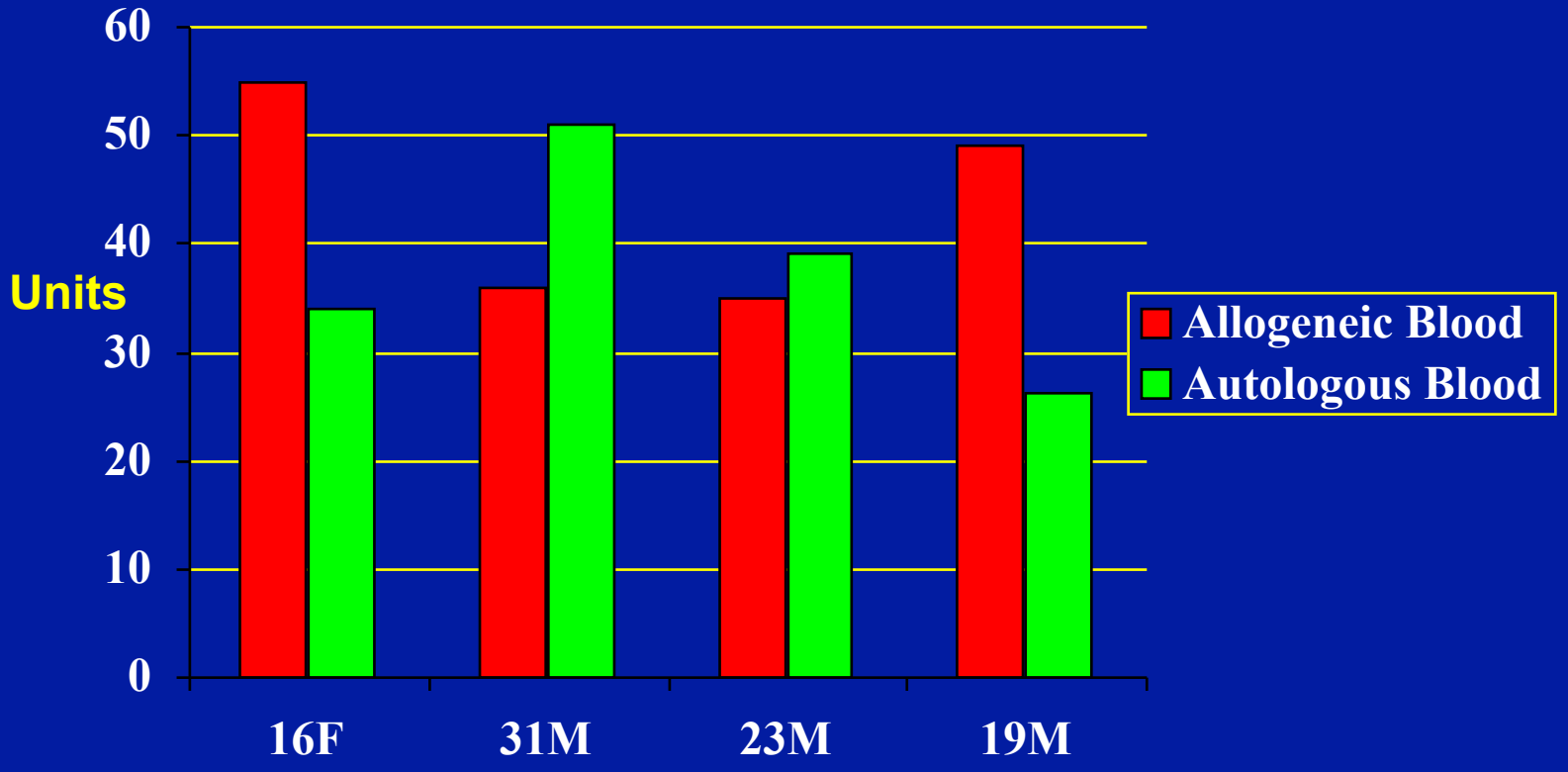
Restoration of oxygen carrying capacity

⇓

Improved survival



Intraoperative Blood Requirements



Gwynne Hughes L, Thomas DW, et al Anaesthesia 2001;56(3): 217-221

Massive Transfusion
10 unit transfusion

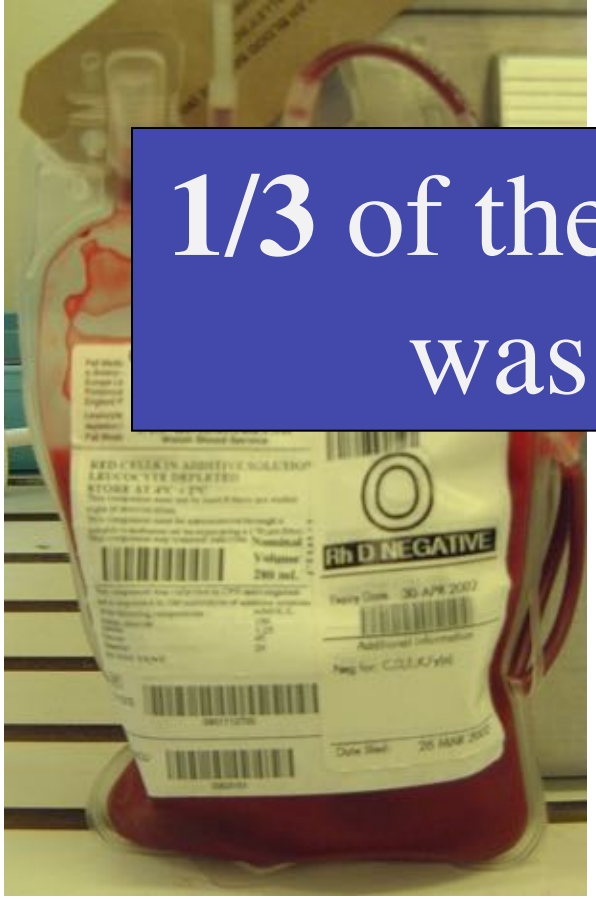
Allogenic RBC's
115 units

Cell salvage 8,785ml

RBC equivalent
35.14 units

2 FO
FREE EYE
The OPTIC
South Wales
SWANSEA
No. 39,823 32p
1, 2001
Injured
es into print
TH
KED
MY
MUM
A SWANSEA accid
who 'died' five time
tal after a crash she
caused by car thiev
ing a book about
ence.
e hurt in crash
2000 Just 149 day
HBACK How the Evening Post reported the
accident in August 1999.

1/3 of the transfusion requirement was met by cell salvage



12cm Em AAA
6 L blood loss\
NO donor RBC Tx
Home in 15 days


500
400
300
200
Moco
LOT 02G29A EXP end 07

Suction induced hemolysis at various vacuum pressures: implications for intraoperative blood salvage

- ? 150 mmHg maximum suction?
- 300 mmHg can bue used if rate of bleeding insists.
- RBC count, hematcrit, serum K+ did notchange significantly
- Hemolysis 0.3- 3 % whether air was suctioned or not

Gregoretti S. Transfusion 1996;36:57-60

Modification of suction induced hemolysis during cell salvage

- Reduction in blood damage CAN be obtained by diluting blood with normal saline while suctioning it from surgical field.

Waters JS et al Anesth Analg 2007;104:684-7

Does swab washing increase the efficiency of red cell recovery by cell salvage in aortic surgery

- Washing swabs improves the efficiency of red cell recovery
- 50.1g return by suction
- 31g return from swab washing
- Therefore a 31% yeild of total form swab washing

Haynes SL et al Vox Sanguinis 2005;88:244-248

UK Intraoperative Cell Salvage Action Group

Technical Factsheet

SWAB WASHING

AREA of APPLICATION

The efficiency of red cell recovery by cell salvage is very much dependent on the ability to recover the blood lost in a useable form. During surgery, blood loss can be removed from the operative site by a combination of suction and swabs. Blood loss to swabs during surgery has been estimated at between 30%[1] and 50%[2] of the total surgical blood loss. By washing swabs, the blood that is normally discarded can be collected and the overall efficiency of red cell recovery improved.[3]

STAFF

Theatre staff

PROCEDURE:

1. Set up a sterile bowl with 1000ml sterile IV grade 0.9% saline*.
2. Soak blood soiled swabs† for a few minutes in the saline to extract red cells. Gently compress the swabs to express any residual solution before discarding.
3. At the end of the procedure‡ aspirate the swab wash solution into the cell salvage reservoir using the suction line. The swab wash should not be left for more than 6 hours without processing.

Notes

If blood loss is to be calculated by weight of blood in the swabs, the swabs will need to be weighed aseptically in the sterile field prior to washing. This can be achieved by placing digital scales within a sterile transparent plastic bag.

* Some centres use anticoagulant in the swab wash e.g. 10,000 IU heparin per litre saline.

†Avoid washing swabs contaminated with betadine or other substances contraindicated in cell salvage.

Version 1
November 2007


With thanks to the team
Efo diolch i’r têm

It saves blood ✓✓✓

All Wales Intra-Operative Cell Salvage Data Collection Form

This form should be completed for every surgical case where blood has been collected with the intention of intra-operative cell salvage EVEN if the blood collected is not processed.

1. Trust	Hospital	Code No.

2. Patient Details			3. Procedure details	
Hospital number			Name of procedure	
Surname				
Forename			Date of operation / / /	
Gender	☐ Male	☐ Female	☐ In hours	☐ Emergency
Address			☐ Out of hours	☐ Elective
			☐ Malignancy	☐ Infected fields
			☐ Obstetrics	☐ Trauma
			Surgeon	
			Anaesthetist	
D.O.B.			Cell Salvage Operator	

4. Cell Saver Equipment Used			
☐ Cobe/Dideco	☐ Haemonetics	☐ CATS	☐ Other
Anti-coag used	☐ Heparin	☐ Citrate	☐ Other
Blood filter used	☐ 40μ filter	☐ Leucodepletion filter	

5. Reason why collection set was used but the blood was not processed		
☐ Inadequate volume collection	☐ Training purposes	☐ Technical problem
Equipment used (unprocessed cases only)		
☐ Collection reservoir	Lot No.	
☐ Whole set	Lot No.	

6. Blood Volume Details			
Total volume processed (ml)		Time collection started	
Volume packed RBC produced (ml)		Time processing started	
Volume packed RBC transfused (ml)		Time transfusion started	
Volume of anticoagulant used (ml)		Number bank RBC units given	
Estimated total blood loss (ml)		Number bank FFP units given	
		Number bank platelet units given	

Why were additional components given

7. Comments / Problems / Critical incidents (please use another sheet if required)

Top copy - – Patient notes **2nd copy** – Audit form - WBS

It saves blood ✓✓✓

Are we over using it?

Changing Practice

Targeted use

Umbrella principle

Products available

- Unwashed collection systems
  - Exactly that wound blood collected and re-infused with filtration
- Washed
  - Anticoagulated, washed and concentrated by centrifugal force and filtered (Continuous and discontinuous)

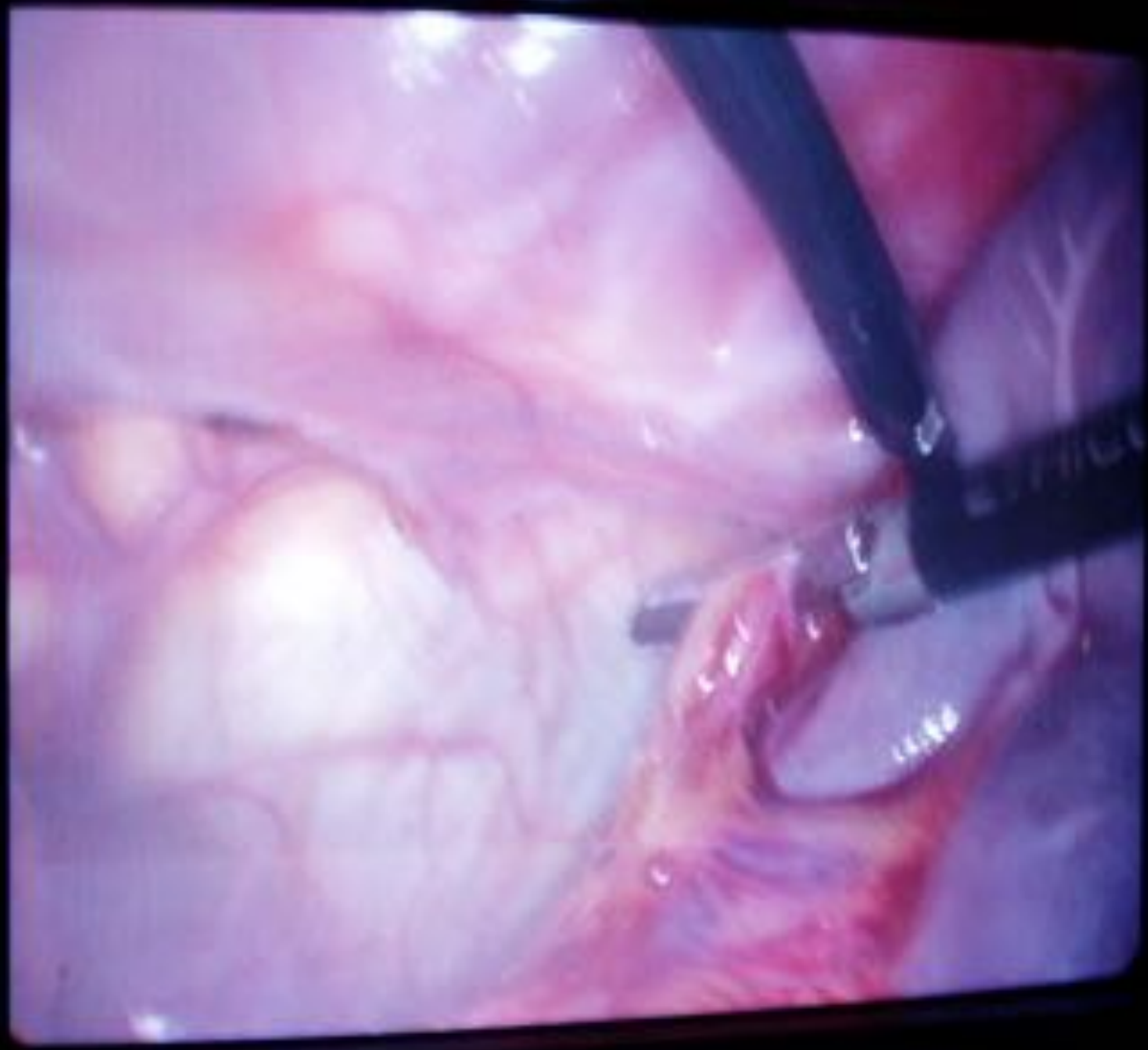
Unwashed shed blood should we transfuse it?

SHOT and UKCSAG ….will provide us with haemovigilance data with a definative solution to the dilema. ……

Liumbruno GM, Waters JH
Blood Transfusion 2011 9(3):241-245

Has the debate been decided?

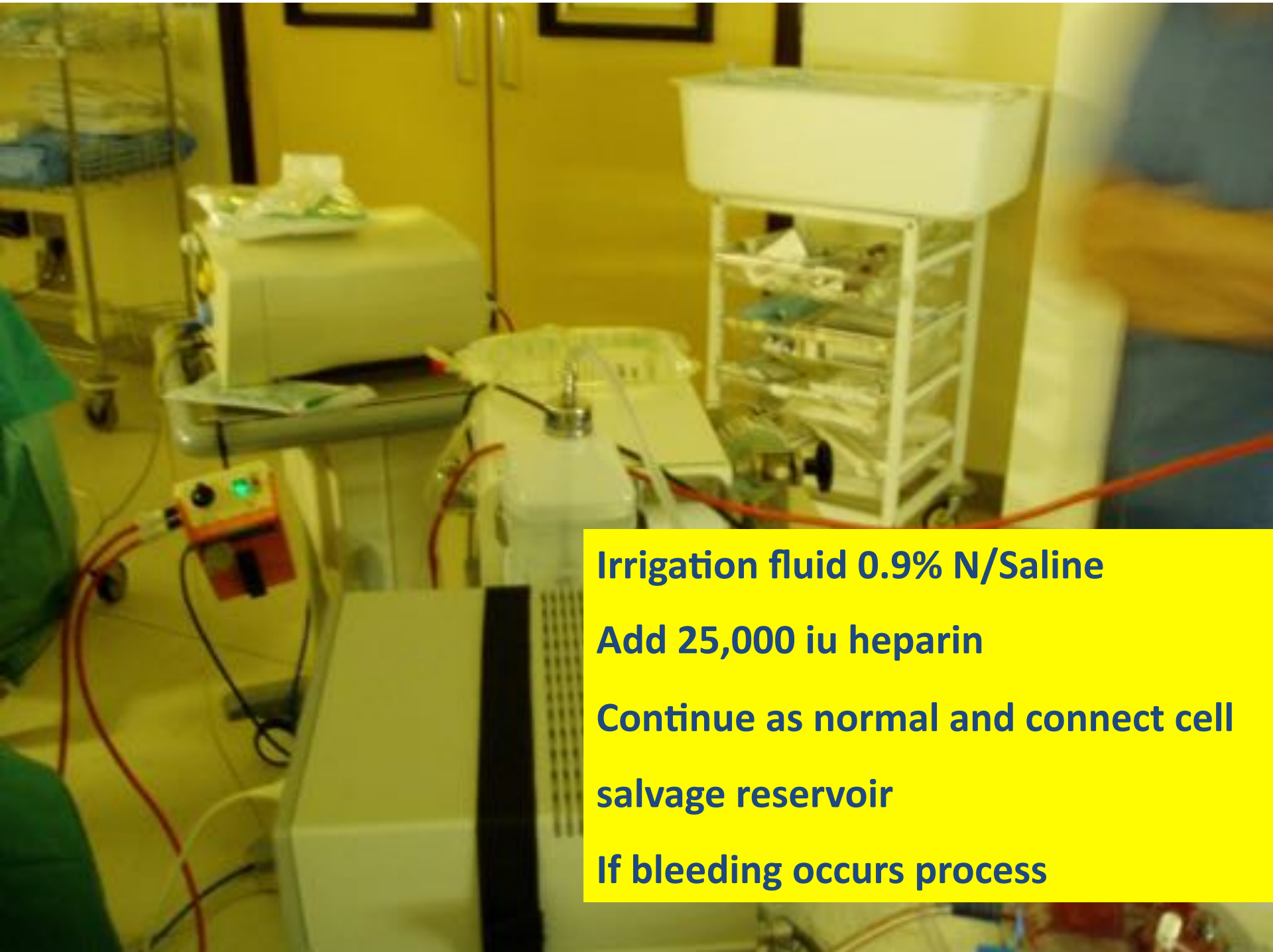
- To drain or not to drain?
- Use of Tranexamic acid
- Better pre-op preparation
- Withholding transfusion
- More targeted use of cell salvage?
- Use of post op salvage in Cardiac surgery?

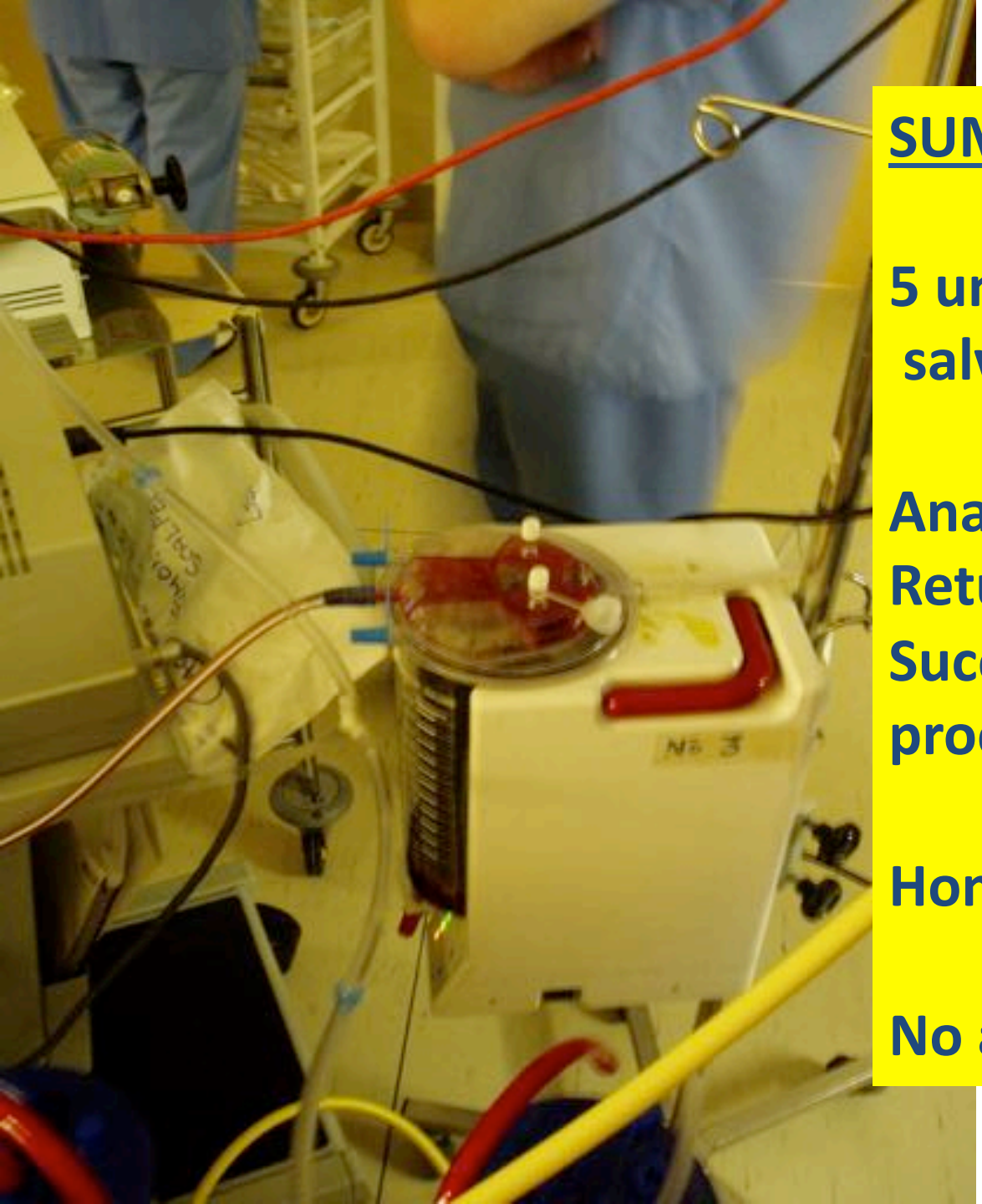


Laparoscopic splenic biopsy

Laparoscopic splenectomy

Massive haemorrhage


Irrigation fluid 0.9% N/Saline
Add 25,000 iu heparin
Continue as normal and connect cell
salvage reservoir
If bleeding occurs process



SUMMARY

5 unit equivalent Tx of salvaged red cells

Anaesthesia reversed
Returned to general ward
Successful laparoscopic procedure

Home shortly afterwards

No allogeneic transfusion

JAMA 1986: 256; 2378-80

- “ Blood potentially contaminated with malignant cells should not be re-infused because of the risk of producing metastases”
- this has not been substantiated by any subsequent in vitro or in vivo work over 28 years.

JAMA 1986: 256; 2378-80

- Cancer
- Obstetrics
- Contamination

April 2008 - NICE approves use of cell salvage in urological malignancy

- Intraoperative red blood cell salvage during radical prostatectomy or radical cystectomy. London: NICE, 2008.
- http://www.nice.org.uk
- “ _ **this procedure is safe enough and works well enough for use in the NHS”**

UK Intraoperative Cell Salvage Action Group

Technical Factsheet

INTRAOPERATIVE CELL SALVAGE IN OBSTETRICS

AREA of APPLICATION

Intraoperative Cell Salvage (ICS) is being increasingly used in the UK in obstetrics for women at risk from postpartum haemorrhage during caesarean section. In the year 2005-2006, 38% of UK maternity units used ICS, and 28% included the use of ICS in their Massive Obstetric Haemorrhage (MOH) protocol. Early theoretical concerns over amniotic fluid embolism have not been borne out in clinical practice and 80% of maternity units identified the barrier to more use as lack of training rather than safety concerns[1].

STAFF

All staff operating the salvage systems

PROCEDURE:

The use of ICS in obstetrics has been endorsed by:

- Confidential Enquiry into Maternal and Child Health (CEMACH)[2]
- Joint AAGBI/OAA Guidelines[3]
- National Institute of Clinical Excellence (NICE)[4]

It is strongly recommended that any health care professional involved with obstetric ICS be familiar with all relevant guidelines.

1. Patient Selection and Preparation

Wherever possible, the advantages and risks of ICS and allogeneic blood transfusion should be discussed with the patient prior to undergoing an obstetric surgical procedure. In a pre-planned case this can be done during antenatal care. It is recommended that patients receive the Intraoperative Cell Salvage Patient Information Leaflet and a copy of the Frequently Asked Questions sheet.

The NICE guidance "Intraoperative blood cell salvage in obstetrics" recommends that "whenever possible, the woman understands what is

Version 1
November 2007

Cell Salvage in Obstetrics N.I.C.E. Guidelines Nov 2005

- …efficacious technique for blood replacement…..
- …use well established in other areas of medicine….
- …..*theoretical* safety concerns when used in obstetrics….
- …so……

- Cell salvage is being used widely in the UK

- There have been ***no reports*** to SHOT or MHRA of any adverse outcomes in cell salvage in obstetrics relating to amniotic fluid embolism

DOI: 10.1111/j.1471-0528.2009.02129.x
www.blackwellpublishing.com/bjog

Review article

Cell salvage at caesarean section: the need for an evidence-based approach

J Geoghegan,[a] JP Daniels,[b] PAS Moore,[c] PJ Thompson,[d] KS Khan,[e] AM Gülmezoglu[f]

[a] Department of Anaesthetics, University Hospital Birmingham NHS Foundation Trust, Edgbaston, Birmingham, UK [b] University of Birmingham Clinical Trials Unit, Edgbaston, Birmingham, UK [c] Department of Anaesthetics, University Hospital Birmingham NHS Foundation Trust, Edgbaston, Birmingham, UK [d] Birmingham Women's Hospital Foundation Trust, Edgbaston, Birmingham, UK [e] Department of Obstetrics and Gynaecology and Clinical Epidemiology, Birmingham Women's Hospital Foundation Trust, Edgbaston, Birmingham, UK [f] UNDP/UNFPA/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction, World Health Organization, Geneva, Switzerland

Correspondence: J Geoghegan, Specialist Registrar in Anaesthetics, Department of Anaesthetics, University Hospital Birmingham NHS Foundation Trust, Edgbaston, Birmingham, UK. Email dr.geoghegan@gmail.com

Accepted 19 January 2009.

Haemorrhage, a leading cause of maternal morbidity and mortality, is frequently associated with caesarean section. Allogeneic blood is an increasingly rare and scare resource. Intraoperative Cell Salvage (IOCS) offers the possibility of improving outcome and reducing allogeneic blood transfusion in cases of haemorrhage at caesarean section. The available literature on the use of IOCS in obstetrics demonstrates that there is limited evidence to support or refute the use of IOCS at caesarean section. However, this procedure has been introduced into obstetric practice. Before opinions about its use become solidified, there is a window of opportunity to launch a large multicentre randomised controlled trial to address the current equipoise.

Keywords Autologous transfusion, caesarean section, cell salvage, intraoperative, obstetrics.

Clinical scenario

- **Profound hypotension**
- **All when LDF being used**
- **Citrate used as anticoagulant**
- **Warm Blood**
- **? Blood being pressurised**
- **BP restored on stopping infusion**

Clinical scenario

Theoretical explanation of hypotensive reports when using LDF's

Clinical scenario

- **Profound hypotension**
- **Bradykinin release, cytokine effect**
- **Seen in LDF at bedside**
- **Anaesthetists need to be made aware**
- **Stop infusion, vasoconstrictors, other fluid.**
- **Transient**
- **Remove filter in urgent situation**

Iwama H. Bradykinin-associated reactions in white cell-reduction filter. *Journal of Critical Care* 2001; 16(2): 74-81.

Bradykinin-Associated Reactions in White Cell-Reduction Filter

Hiroshi Iwama

Purpose: The purpose of this study was to examine the effect of temperature on bradykinin generation during blood transfusion using positively charged (positive filter), negatively charged (negative filter), and neutral (neutral filter) filters.

Materials and Methods: Whole blood collected from six volunteers at 4°C or 37°C was passed through the positive or negative filter. In six surgical patients during surgery, autologous blood transfusion at 37°C was initiated through the positive filter, and the same transfusion was reintroduced through the negative filter. Whole blood from another six volunteers at 4° or 37°C was passed through the neutral filter.

Results: The positive filter did not generate bradykinin at any temperature, whereas the negative filter generated bradykinin by approximately 4,000-fold when warm blood was used but did not at cool blood. Blood pressure decreased and heart rate increased during warm blood transfusion using the negative filter but did not change using the positive filter. Plasma bradykinin levels increased in patients with use of the negative filter. The neutral filter generated bradykinin when warm blood was used but at levels lower than for the negative filter.

Conclusions: Use of negative filter results in the temperature-dependent generation of bradykinin, which becomes a potential anaphylatoxin when warm blood is used.

Enteric contamination

- Timberlake GA McSain NEJr Autotransfusion of blood contaminated by entericcontents:a potentially life saving measure in the massively haemorrhaging trauma patient? J Trauma 1988:28(6):855-857.
- Ozman V McSwain NE Jr ichols RL et al. Autotransfusion of potentially culture-positive blood (CPB) in abdominal trauma: preliminary data from a prospective study. J Trauma 1992;32(1): 36-39.
  - Smith LA, Barker DE Burns RP. Autotransfusion utilisation in abdominal trauma. Am Surg 1997; 63(!):47-49.
- Hughes LG, Thomas DW, Wareham K, et al. Intra-operative blood salvage in Abdominal trauma:a review of 5 years' experience. Anaesthsia 2001;56(3):217-220.
- Intraoperative Blood Salvage in Penetrating Abdominal Trauma:a Randomised, Controlled Trial. Bowley DM et al.World Journal of Surgery2006;30:1074-1080

Intraoperative Blood Salvage in Penetrating Abdominal Trauma:a Randomised, Controlled Trial

- Those patients with penetrating torso injury requiring laparotomy
- Hypotensive either pre—hospital or on arrival
- Significant blood loss considered.

Bowley DM et al.World Journal of Surgery2006;30:1074-1080

Intraoperative Blood Salvage in Penetrating Abdominal Trauma:a Randomised, Controlled Trial

- Assuming a 40% reduction of blood requirement with SD of 4.5 units for a power of 80% and type 1 error rate of 5% 20 patients in each arm needed.

Bowley DM et al.World Journal of Surgery2006;30:1074-1080

Intraoperative Blood Salvage in Penetrating Abdominal Trauma:a Randomised, Controlled Trial

- Randomised to two groups.
- Allogeneic only
- ICS plus allogeneic if required
- All had prophylactic antibiotics
- Primary outcome was Blood Tx

Bowley DM et al.World Journal of Surgery2006;30:1074-1080

Intraoperative Blood Salvage in Penetrating Abdominal Trauma:a Randomised, Controlled Trial

- 23 pts (Control) and 21 pts(ICS)

  1493ml (0-2,690)

Allogeneic Blood

- 11.17units 6.47units **P=0.008**

Bowley DM et al.World Journal of Surgery2006;30:1074-1080

Intraoperative Blood Salvage in Penetrating Abdominal Trauma:a Randomised, Controlled Trial

- Enteric injury
  - –17/23 (75%) 18/21 (85%)
- Survival
  - –8/23 (35%) 7/21 (33%)
  - –Sepsis similar in both groups but if sepsis developed more likely to die.

Bowley DM et al.World Journal of Surgery2006;30:1074-1080

Intraoperative Blood Salvage in Penetrating Abdominal Trauma:a Randomised, Controlled Trial

- Enteric injury
  - –17/23 (75%) 18/21 (85%)
- Survival
  - –8/23 (35%) 7/21 (33%)
  - –Sepsis similar in both groups but if sepsis developed more likely to die.

Bowley DM et al.World Journal of Surgery2006;30:1074-1080

Who benefits from red blood cell salvage? Utility and value of intraoperative autologous transfusion Editorial Transfusion

- Jonathan Water's paper on of a case series of 20,000 cases over 5 years
- Morriston has single centre data over 20 years of 18,000 cases and All Wales data from 2006 of another 18,000
- Unsuprisingly we have come to almost identical conclusions

Editorial Transfusion 2011;51:2058:2060

Who benefits from red blood cell salvage? Utility and value of intraoperative autologous transfusion Editorial Transfusion

- A significant proportion of cases have a low yield of less than 1 unit equivalent.
- Lumbar spine surgery covers a spectrum of invasiveness which will result in a wide variation in blood loss
- Must agree that surgical technique and skill has improved

Editorial Transfusion 2011;51:2058:2060

Who benefits from red blood cell salvage? Utility and value of intraoperative autologous transfusion

- Over 5 year period 31,351 rbc units were spared amounting to a dollar equivalent of $6.7 M
- Even when costs of running the programme are deducted a net cost saving of $2.3M
- Per institution saving $35,517 per year

Editorial Transfusion 2011;51:2058:2060

Cell salvage intra-operatively and postoperatively – worth a go?

Yes BUT

Case selection very important and will vary between institutions

Certain procedures will be non cost effective

The ease of emergency use if you have a trained and competent team and have an elective service running

Reservoir costs need to come down

Cell salvage intra-operatively and postoperatively – worth a go?

Yes BUT

Reservoir costs need to come down

As in sudden haemorrhage much blood can be lost in the 10-15 min set up time

The remainder of he harness does not need to be opened if collection volume is low