Practice Guidelines for Perioperative Blood Management: An Updated Report
American Society of Anesthesiologists

Bibliography by Section

I. Preoperative patient evaluation

Reviewing medical records (patient condition).

Observational studies, case reports, or comparisons without pertinent control groups

1. Benoist S, Panis Y, Pannegeon V, Alves A, Valleur P: Predictive factors for perioperative blood transfusions in rectal resection for cancer: A multivariate analysis of a group of 212 patients. Surgery 2001; 129:433-439
2. Bjessmo S, Ivert T: Blood loss after coronary artery bypass surgery: relations to patient variables and antithrombotic treatment. Scand Cardiovasc J 2000; 34:438-445
3. Bocchieri KA, Scheinerman SJ, Graver LM: Exchange transfusion before cardiopulmonary bypass in sickle cell disease. Ann Thorac Surg 2010; 90:323-324
4. Cash KL, Brown T, Sausais L, Uehlinger J, Reed LJ: Severe delayed hemolytic transfusion reaction secondary to anti-At(a). Transfusion 1999; 39:834-837
5. De Santo LS, Amarelli C, Della Corte A, Scardone M, Bancone C, Carozza A, Grassia MG, Romano G: Blood transfusion after on-pump coronary artery bypass grafting: focus on modifiable risk factors. Eur J Cardiothorac Surg 2013; 43:359-366
6. Engstrom KG, Appelblad M, Brorsson, B: Mechanisms behind operating room blood transfusions in coronary artery bypass graft surgery patients with insignificant bleeding. J Cardiothorac Vasc Anes 2002; 16:539-544
7. Fox JS, Amaranath L, Hoeltge GA, Andrish JT: Autologous blood transfusion and intraoperative cell salvage in a patient with homozygous sickle cell disease. Cleve Clin J Med 1994; 61:137-140
8. Gaudino M, Luciani N, Piancone FL, Bruno P, Rossi M, Schiavello R, Possati G: Perioperative management of a patient with Werlhof disease undergoing myocardial revascularization. J Cardiovasc Surg (Torino) 1999; 40:227-228
9. Gerrah R, Shargal Y, Elami A: Impaired oxygenation and increased hemolysis after cardiopulmonary bypass in patients with glucose-6-phosphate dehydrogenase deficiency. Ann Thorac Surg 2003; 76:523-527
10. Hendriks HG, van der Meer J, Klompmaker IJ, Choudhury N, Hagenaars JA, Porte RJ, de Kam PJ, Slooff MJ, de Wolf JT: Blood loss in orthotopic liver transplantation: a retrospective analysis of transfusion requirements and the effects of autotransfusion of cell saver blood in 164 consecutive patients. Blood Coagul Fibrinolysis 2000; 11:S87-S93
11. Katz K, Tamary H, Lahav J, Soudry M, Cohen IJ: Increased operative bleeding during orthopaedic surgery in patients with type I Gaucher disease and bone involvement. Bull Hosp Jt Dis 1999; 58:188-190
12. Lindgren L, Yli-Hankala A, Halme L, Koskimies S, Orko R: Transfusion-related acute lung injury (TRALI) after fresh frozen plasma in a patient with coagulopathy. Acta Anaesthesiol Scand 1996; 40:641-644
13. Lison S, Spannagl M, Dietrich W: Hemophilia A in cardiac operations: a model of reduced thrombin generation. Ann Thorac Surg 2011; 91:1606-1608
14. Netzer G, Shah CV, Iwashyna TJ, Lanken PN, Finkel B, Fuchs B, Guo W, Christie JD: Association of RBC transfusion with mortality in patients with acute lung injury. Chest 2007; 132:1116-1118

15. Pagani FD, Polito RJ, Bolling SF: Mitral valve reconstruction in sickle cell disease. Ann Thorac Surg 1996; 61:1841-1843
16. Potter PS, Waters JH, Burger GA, Mraovic B: Application of cell-salvage during cesarean section. Anesthesiology 1999; 90:619-621
17. Sutton SW, Hunley EK, Duncan MA, Rodriguez R, Meyers TP: Sickle cell disease and aortic valve replacement: use of cardiopulmonary bypass, partial exchange transfusion, platelet sequestration, and continuous hemofiltration. Tex Heart Inst J 1999; 26:283-288
18. Uen WC, Chou YH, Liu CC, Lin SM, Chen TJ: Successful resection of sigmoid colon cancer in a patient with factor XI deficiency. J Formos Med Assoc 1998; 97:283-285
19. Vichinsky EP, Haberkern CM, Neumayr L, Earles AN, Black D, Koshy M, Pegelow C, Abboud M, Ohene-Frempong K, Iyer RV: A comparison of conservative and aggressive transfusion regimens in the perioperative management of sickle cell disease. The Preoperative Transfusion in Sickle Cell Disease Study Group. N Engl J Med 1995; 333:206-213
20. Walsh TS, Palmer J, Watson D, Biggin K, Seretny M, Davidson H, Harkness M, Hay A: Multicentre cohort study of red blood cell use for revision hip arthroplasty and factors associated with greater risk of allogeneic blood transfusion. Br J Anaesth 2012; 108:63-71

Laboratory tests.

Hemoglobin or hematocrit to identify preoperative anemia:

Observational studies, case reports, or comparisons without pertinent control groups

1. Karkouti K, Wijeysundera DN, Beattie WS: Risk associated with preoperative anemia in cardiac surgery: A multicenter cohort study. Circulation 2008; 117:478-484
2. Karkouti K, Wijeysundera D, Yau T, McCluskey S, Chan C, Wong P-Y, Beattie WS: Influence of erythrocyte transfusion on the risk of acute kidney injury after cardiac surgery differs in anemic and nonanemic patients. Anesthesiology 2011; 115:523-530
3. Kohli N, Mallipeddi PK, Neff JM, Sze EH, Roat TW: Routine hematocrit after elective gynecologic surgery. Obstet Gynecol 2000; 95:847-850
4. Kulier A, Levin J, Moser R, Rumpold-Seitlinger G, Tudor IC, Snyder-Ramos SA, Moehnle P, Mangano DT: Impact of preoperative anemia on outome in patients undergoing coronary artery bypass graft surgery. Circulation 2007; 116:471-479
5. LeRoux PD, Elliott JP, Winn HR: Blood transfusion during aneurysm surgery. Neurosurgery 2001; 49:1068-1075
6. Musallam KM, Tamim HM, Richards T, Spahn DR, Rosendaal FR, Habbal A, Khreiss M, Dahdaleh FS, Khavandi K, Sfeir PM, Soweid A, Hoballah JJ, Taher AT, Jamali FR: Preoperative anaemia and postoperative outcomes in non-cardiac surgery: a retrospective cohort study. Lancet 2011; 378:1396-1407
7. Pirat A, Sargin D, Torgay A, Arslan G: Identification of preoperative predictors of intraoperative blood transfusion requirement in orthotopic liver transplantation. Transplant Proc 2002; 34:2153-2155
8. Williams GD, Bratton SL, Riley EC, Ramamoorthy C: Coagulation tests during cardiopulmonary bypass correlate with blood loss in children undergoing cardiac surgery. J Cardiothorac Vasc Anesth 1999; 13:398-404

Coagulation profile (PT, aPTT, activated coagulation time [ACT], thromboelastogram [TEG]):

Observational studies, case reports, or comparisons without pertinent control groups

1. Brener SJ, Bhatt DL, Moliterno DJ, Schneider JP, Ellis SG, Topol EJ: Revisiting optimal anticoagulation with unfractionated heparin during coronary stent implantation. Am J Cardiol 2003; 92:1468-1471
2. Despotis GJ, Levine V, Filos KS, Santoro SA, Joist JH, Spitznagel E, Goodnough LT: Evaluation of a new point-of-care test that measures PAF-mediated acceleration of coagulation in cardiac surgical patients. Anesthesiology 1996; 85:1311-1323
3. Ereth MH, Nuttall GA, Klindworth JT, MacVeigh I, Santrach PJ, Orszulak TA, Harmsen WS, Oliver W Jr: Does the platelet-activated clotting test (Hemo-STATUS) predict blood loss and platelet dysfunction associated with cardiopulmonary bypass? Anesth Analg 1997; 85:257-264
4. Ereth MH, Nuttall GA, Santrach PJ, Klindworth JT, Oliver WC Jr, Schaff HV: The relation between the platelet-activated clotting test (HemoSTATUS) and blood loss after cardiopulmonary bypass. Anesthesiology 1998; 88:962-969
5. Gelb AB, Roth RI, Levin J, London MJ, Noall RA, Hauck WW, Cloutier M, Verrier E, Mangano DT: Changes in blood coagulation during and following cardiopulmonary bypass. Am J Clin Pathol 1996; 106:87-99
6. Gravlee GP, Arora S, Lavendar SW, Mills SA, Hudspeth AS, Cordell AR, James RL, Brockschmidt JK, Stuart JJ: Predictive value of blood clotting tests in cardiac surgical patients. Ann Thorac Surg 1994; 58:216-221
7. Horlocker TT, Nuttall GA, Dekutoski MB, Bryant SC: The accuracy of coagulation tests during spinal fusion and instrumentation. Anesth Analg 2001; 93:33-38
8. Karkouti K, McCluskey SA, Syed S, Pazaratz C, Poonawala H, Crowther MA: The influence of perioperative coagulation status on postoperative blood loss in complex cardiac surgery: a prospective observational study. Anesth Analg 2010; 110:1533-1540
9. Murray D, Pennell B, Olson J: Variability of prothrombin time and activated partial thromboplastin time in the diagnosis of increased surgical bleeding. Transfusion 1999; 39:56-62
10. Myers ER, Clarke-Pearson DL, Olt GJ, Soper JT, Berchuck A: Preoperative coagulation testing on a gynecologic oncology service. Obstet Gynecol 1994; 83:438-444
11. Nuttall GA, Oliver WC, Beynen FM, Santrach PJ, Strickland RA, Murray MJ: Determination of normal versus abnormal activated partial thromboplastin time and prothrombin time after cardiopulmonary bypass. J Cardiothorac Vasc Anesth 1995; 9:355-361
12. Nuttall GA, Oliver WC, Ereth MH, Santrach PJ: Coagulation tests predict bleeding after cardiopulmonary bypass. J Cardiothorac Vasc Anesth 1997; 11:815-823
13. Reich DL, Yanakakis MJ, Vela-Cantos FP, DePerio M, Jacobs E: Comparison of bedside coagulation monitoring tests with standard laboratory tests in patients after cardiac surgery. Anesth Analg 1999; 88:312-319

II. Preadmission patient preparation

Prevention/reduction of perioperative anemia.

Erythropoietin:

Randomized controlled trials; erythropoietin vs. placebo

1. Aksoy MC, Tokgozoglu AM: Erythropoietin for autologous blood donation in total hip arthroplasty patients. Arch Orthop Trauma Surg 2001; 121:162-165
2. de Andrade JR, Jove M, Landon G, Frei D, Guilfoyle M, Young DC: Baseline hemoglobin as a predictor of risk of transfusion and response to Epoetin alfa in orthopedic surgery patients. Am J Orthop 1996; 25:533-542
3. de Pree C, Mermillod B, Hoffmeyer P, Beris P: Recombinant human erythropoietin as adjuvant treatment for autologous blood donation in elective surgery with large blood needs ($\geq$ 5 units): a randomized study. Transfusion 1997; 37:708-714
4. Faris PM, Ritter MA, Abels RI: The effects of recombinant human erythropoietin on perioperative transfusion requirements in patients having a major orthopaedic operation. The American Erythropoietin Study Group. J Bone Joint Surg Am 1996; 78:62-72
5. Feagan BG, Wong CJ, Kirkley A, Johnston DW, Smith FC, Whitsitt P, Wheeler SL, Lau CY: Erythropoietin with iron supplementation to prevent allogeneic blood transfusion in total hip joint arthroplasty. A randomized, controlled trial. Ann Intern Med 2000; 133:845-854
6. Goodnough LT, Price TH, Friedman KD, Johnston M, Ciavarella D, Khan N, Sacher R, Vogler WR, Wissel M, Abels RI: A phase III trial of recombinant human erythropoietin therapy in non-anemic orthopedic patients subjected to aggressive removal of blood for autologous use: Dose, response, toxicity, and efficacy. Transfusion 1994; 34:66-71
7. Hayashi J, Kumon K, Takanashi S, Kawashima Y, Eguchi S, Takaku F, Yamamura H: Subcutaneous administration of recombinant human erythropoietin before cardiac surgery: a double-blind, multicenter trial in Japan. Transfusion 1994; 34:142-146
8. Heiss MM, Tarabichi A, Delanoff C, Allgayer H, Jauch KW, Hernandez-Richter T, Mempel W, Beck KG, Schildberg FW, Messmer K: Perisurgical erythropoietin application in anemic patients with colorectal cancer: A double-blind randomized study. Surgery 1996; 119:523-527
9. Kettelhack C, Hones C, Messinger D, Schlag PM: Randomized multicentre trial of the influence of recombinant human erythropoietin on intraoperative and postoperative transfusion need in anaemic patients undergoing right hemicolectomy for carcinoma. Br J Surg 1998; 85:63-67
10. Kosmadakis N, Messaris E, Maris A, Katsaragakis S, Leandros E, Konstadoulakis MM, Androulakis G: Perioperative erythropoietin administration in patients with gastrointestinal tract cancer: prospective randomized double-blind study. Ann Surg 2003; 237:417-421
11. Mercuriali F, Inghilleri G, Biffi E, Colotti MT, Vinci A, Oriani G: Epoetin alfa in low hematocrit patients to facilitate autologous blood donation in total hip replacement: a randomized, double-blind, placebo-controlled, dose-ranging study. Acta Haematol 1998; 100:69-76
12. Price TH, Goodnough LT, Vogler W, Sacher RA, Hellman RM, Johnston MF, Bolgiano DC, Abels RI: The effect of recombinant human erythropoietin on the efficacy of autologous blood donation in patients with low hematocrits: A multicenter, randomized, double-blind controlled trial. Transfusion 1996; 36:29-36

13. Qvist N, Boesby S, Wolff B, Hansen CP: Recombinant human erythropoietin and hemoglobin concentration at operation and during the postoperative period: reduced need for blood transfusions in patients undergoing colorectal surgery--prospective double-blind placebo-controlled study. World J Surg 1999; 23:30-35
14. Scott SN, Boeve TJ, McCulloch TM, Fitzpatrick KA, Karnell LH: The effects of epoetin alfa on transfusion requirements in head and neck cancer patients: a prospective, randomized, placebo-controlled study. Laryngoscope 2002; 112:1221-1229
15. Shapiro GS, Boachie-Adjei O, Dhawlikar SH, Maier LS: The use of Epoetin alfa in complex spine deformity surgery. Spine 2002; 27:2067-2071
16. Sowade O, Warnke H, Scigalla P, Sowade B, Franke W, Messinger D, Gross J: Avoidance of allogeneic blood transfusions by treatment with epoetin beta (recombinant human erythropoietin) in patients undergoing open-heart surgery. Blood 1997; 89:411-418
17. Sowade O, Ziemer S, Sowade B, Franke W, Messinger D, Ziebell E, Scigalla P, Warnke H: The effect of preoperative recombinant human erythropoietin therapy on platelets and hemostasis in patients undergoing cardiac surgery. J Lab Clin Med 1997; 129:376-383
18. Walpoth B, Galliker B, Spirig P, Haeberli A, Rosenmund A, Althaus U, Nydegger UE: Use of epoetin alfa in autologous blood donation programs for patients scheduled for elective cardiac surgery. Semin Hematol 1996; 33(2 Suppl 2):75-76
19. Yoo YC, Shim JK, Kim JC, Jo YY, Lee JH, Kwak YL: Effect of single recombinant human erythropoietin injection on transfusion requirements in preoperatively anemic patients undergoing valvular heart surgery. Anesthesiology 2011; 115:929-937

Randomized controlled trials; erythropoietin vs. no erythropoietin

20. Biesma DH, Marx JJ, Kraaijenhagen RJ, Franke W, Messinger D, van de Wiel A: Lower homologous blood requirement in autologous blood donors after treatment with recombinant human erythropoietin. Lancet 1994; 344:367-370
21. Braga M, Gianotti L, Vignali A, Gentilini O, Servida P, Bordignon C, Di Carlo V: Evaluation of recombinant human erythropoietin to facilitate autologous blood donation before surgery in anaemic patients with cancer of the gastrointestinal tract. Br J Surg 1995; 82:1637-1640
22. Christodoulakis M, Tsiftsis DD: Preoperative epoetin alfa in colorectal surgery: a randomized, controlled study. Ann Surg Oncol 2005; 12:718-725
23. Hyllner M, Avall A, Swolin B, Bengtson JP, Bengtsson A: Autologous blood transfusion in radical hysterectomy with and without erythropoietin therapy. Obstet Gynecol 2002; 99:757-762
24. Kajikawa M, Nonami T, Kurokawa T, Hashimoto S, Harada A, Nakao A, Takagi H: Autologous blood transfusion for hepatectomy in patients with cirrhosis and hepatocellular carcinoma: use of recombinant human erythropoietin. Surgery 1994; 115:727-734
25. Podesta A, Carmagnini E, Parodi E, Dottori V, Crivellari R, Barberis L, Audo A, Lijoi A, Passerone G: Elective coronary and valve surgery without blood transfusion in patients treated with recombinant human erythropoietin (epoetin-alpha). Minerva Cardioangiol 2000; 48:341-347
26. Stowell CP, Jones SC, Enny C, Langholff W, Leitz G: An open-label, randomized, parallel-group study of perioperative epoetin alfa versus standard of care for blood conservation in major elective spinal surgery: safety analysis. Spine (Phila Pa 1976) 2009; 34:2479-2485

27. Tsuji Y, Kambayashi J, Shiba E, Sakon M, Kawasaki T, Mori T: Effect of recombinant human erythropoietin on anaemia after gastrectomy: a pilot study. Eur J Surg 1995; 161:29-33
28. Weber EW, Slappendel R, Hémon Y, Mähler S, Dalén T, Rouwet E, van Os J, Vosmaer A, van der Ark P: Effects of epoetin alfa on blood transfusions and postoperative recovery in orthopaedic surgery. Eur J Anaesthesiol 2005; 22:249-257
29. Weltert L, D'Alessandro S, Nardella S, Girola F, Bellisario A, Maselli D, De Paulis R: Preoperative very short-term, high-dose eryhtropoietin administration diminishes blood transfusion rate in off-pump coronary artey bypass: a randomized blind controlled study. J Thorac Cardiovasc Surg 2010; 139:621-626
30. Wurnig C, Schatz K, Noske H, Hemon Y, Dahlberg G, Josefsson G, Milbrink J, Hamard C; Collaborative Study Group: Subcutaneous low-dose epoetin beta for the avoidance of transfusion in patients scheduled for elective surgery not eligible for autologous blood donation. Eur Surg Res 2001; 33:303-310

Nonrandomized comparative studies; erythropoietin vs. no erythropoietin

1. García-Erce JA, Cuenca J, Haman-Alcober S, Martínez AA, Herrera A, Muñoz M: Efficacy of preoperative recombinant human erythropoietin administration for reducing transfusion requirements in patients undergoing surgery for hip fracture repair. An observational cohort study. Vox Sang 2009; 97:260-267
2. Mercuriali F, Gualtieri G, Sinigaglia L, Inghilleri G, Biffi E, Vinci A, Colotti MT, Barosi G, Lambertengh Deliliers G: Use of recombinant human erythropoietin to assist autologous blood donation by anemic rheumatoid arthritis patients undergoing major orthopedic surgery. Transfusion 1994; 34:501-506
3. Rauh MA, Bayers-Thering M, LaButti RS, Krackow KA: Preoperative administration of epoetin alfa to total joint arthroplasty patients. Orthopedics 2002; 25:317-320

Observational studies, case reports, or non-pertinent comparison groups

1. Chikada M, Furuse A, Kotsuka Y, Yagyu K: Open-heart surgery in Jehovah's Witness patients. Cardiovasc Surg 1996; 4:311-314
2. Gombotz H, Gries M, Sipurzynski S, Fruhwald S, Rehak P: Preoperative treatment with recombinant human erythropoietin or predeposit of autologous blood in women undergoing primary hip replacement. Acta Anaesthesiol Scand 2000; 44:737-742
3. Podesta A, Parodi E, Dottori V, Crivellari R, Passerone GC: Epoetin alpha in elective coronary and valve surgery in Jehovah's Witnesses patients. Experience in 45 patients. Minerva Cardioangio 2002; 50:125-131

Iron:

Randomized controlled trials

1. Andrews CM, Lane DW, Bradley JG: Iron pre-load for major joint replacement. Transfus Med 1997; 7:281-286
2. Garrido-Martín P, Nassar-Mansur MI, de la Llana-Ducrós R, Virgos-Aller TM, Rodríguez Fortunez PM, Ávalos-Pinto R, Jimenez-Sosa A, Martínez-Sanz R: The effect of intravenous and oral iron administration on perioperative anaemia and transfusion requirements in patients undergoing elective cardiac surgery: a randomized clinical trial. Interact Cardiovasc Thorac Surg 2012; 15:1013-1018

3. Weisbach V, Skoda P, Rippel R, Lauer G, Glaser A, Zingsem J, Zimmermann R, Eckstein R: Oral or intravenous iron as an adjuvant to autologous blood donation in elective surgery: a randomized, controlled study. Transfusion 1999; 39:465-472

Observational studies, case reports, or non-pertinent comparison groups

1. Hallak M, Sharon AS, Diukman R, Auslender R, Abramovici H: Supplementing iron intravenously in pregnancy. A way to avoid blood transfusions. J Reprod Med 1997; 42:99-103
2. Okuyama M, Ikeda K, Shibata T, Tsukahara Y, Kitada M, Shimano T: Preoperative iron supplementation and intraoperative transfusion during colorectal cancer surgery. Surg Today 2005; 35:36-40

Discontinuation of anticoagulants.

Warfarin:

Observational studies, case reports, or non-pertinent comparison groups

1. Dotan ZA, Mor Y, Leibovitch I, Varon D, Golomb J, Duvdevani M, Ramon J: The efficacy and safety of perioperative low molecular weight heparin substitution in patients on chronic oral anticoagulant therapy undergoing transurethral prostatectomy for bladder outlet obstruction. J Urol 2002; 168:610-613

Discontinuation of antithrombotics.

Clopidogrel, Ticagralor, Prasugrel or other thienopyridines:

Observational studies, case reports, or non-pertinent comparison groups

1. Firanescu CE, Martens EJ, Schönberger JP, Soliman Hamad MA, van Straten AH: Postoperative blood loss in patients undergoing coronary artery bypass surgery after preoperative treatment with clopidogrel. A prospective randomized controlled study. Eur J Cardiothorac Surg 2009; 36:856-862
2. Miceli A, Duggan SMJ, Aresu G, de Siena PM, Romeo F, Glauber M, Caputo M, Angelini GD: Combined clopidogrel and aspirin treatment up to surgery increases the risk of postoperative myocardial infarction, blood loss and reoperation for bleeding in patients undergoing coronary artery bypass grafting. Eur J Cardio-Thorac Surg 2012; 43:722-728
3. Shim JK, Choi YS, Oh YJ, Bang SO, Yoo KJ, Kwak YL: Effects of preoperative aspirin and clopidogrel therapy on perioperative blood loss and blood transfusion requirements in patients undergoing off-pump coronary artery bypass graft surgery. J Thorac Cardiovasc Surg 2007; 134:59-64

Aspirin:

Observational studies, case reports, or non-pertinent comparison groups

1. Devereaux PJ, Mrkobrada M, Sessler DI, Leslie K, Alonso-Coello P, Kurz A, Villar JC, Sigamani A, Biccard BM, Meyhoff CS, Parlow JL, Guyatt G, Robinson A, Garg AX, Rodseth RN, Botto F, Lurati Buse G, Xavier D, Chan MT, Tiboni M, Cook D, Kumar PA, Forget P, Malaga G, Fleischmann E, Amir M, Eikelboom J, Mizera R, Torres D, Wang CY, VanHelder T, Paniagua P, Berwanger O, Srinathan S, Graham M, Pasin L, Le Manach Y, Gao P, Pogue J, Whitlock R, Lamy A, Kearon C, Baigent C, Chow C, Pettit

S, Chrolavicius S, Yusuf S: Aspirin in patients undergoing noncardiac surgery. N Engl J Med 2014; 370:1494-1503
2. Oscarsson A, Gupta A, Fredrikson M, Jarhult J, Nystrom M, Pettersson E, Darvish B, Krook H, Swahn E, Eintrei C: To continue or discontinue aspirin in the perioperative period: a randomized, controlled clinical trial. Br J Anaesth 2010; 104:305-312

Preadmission Autologous Blood Donation (PAD).

PAD versus allogeneic blood or blood products:

Randomized controlled trials

1. Avall A, Hyllner M, Bengtson JP, Carlsson L, Bengtsson A: Postoperative inflammatory response after autologous and allogeneic blood transfusion. Anesthesiology 1997; 87:511-516
2. Bouchard D, Marcheix B, Al-Shamary S, Vanden Eynden F, Demers P, Robitaille D, Pellerin M, Perrault LP, Carrier M: Preoperative autologous blood donation reduces the need for allogeneic blood products: a prospective randomized study. Can J Surg 2008; 51:422-427
3. Chen G, Zhang FJ, Gong M, Yan M: Effect of perioperative autologous versus allogeneic blood transfusion on the immune system in gastric cancer patients. J Zhejiang Univ Sci B 2007; 8:560-565
4. Hedstrom M, Flordal PA, Ahl T, Svensson J, Dalen N: Autologous blood in hip replacement. No effect on blood loss but less increase of plasminogen activator inhibitor in a randomized series of 80 patients. Acta Orthop Scand 1996; 67:317-320
5. Heiss MM, Mempel W, Delanoff C, Jauch KW, Gabka C, Mempel M, Dieterich HJ, Eissner HJ, Schildberg FW: Blood transfusion-modulated tumor recurrence: first results of a randomized study of autologous versus allogeneic blood transfusion in colorectal cancer surgery. J Clin Oncol 1994: 12:1859-1867
6. Kajikawa M, Nonami T, Kurokawa T, Hashimoto S, Harada A, Nakao A, Takagi H: Autologous blood transfusion for hepatectomy in patients with cirrhosis and hepatocellular carcinoma: use of recombinant human erythropoietin. Surgery 1994; 115:727-734

Nonrandomized comparative studies

1. Giurati G, Zanetta G, Caspani L, Landon F, Pellegrino A, Baglioni S, Mangioni C: Autologous blood transfusion in patients undergoing radical hysterectomy. Br J Obstet Gynaecol 1995; 102:64-65
2. Martin K, Keller E, Gertler R, Tassani P, Wiesner G: Efficiency and safey of preoperative autologous blood donation in cardiac surgery: a matched-pair analysis in 432 patients. Eur J Cardiothorac Surg 2010; 37:1396-1401
3. Oefelein MG, Colangelo LA, Rademaker AW, McVary KT: Intraoperative blood loss and prognosis in prostate cancer patients undergoing radical retropubic prostatectomy. J Urol 1995; 154:442-447
4. Pellegrino A, Landoni F, Cormio G, Ferrando P, Lissoni A, Scalambrino S, Mangioni C: Effectiveness of autologous blood transfusion in patients undergoing radical hysterectomy. Ann Chir Gynaecol 1995; 84:391-394
5. Pinkerton PH, Covens A: Autologous blood transfusion in radical hysterectomy. Transfus Med 1996; 6:223-225

6. Rzyman W, Dziadziuszko R, Skokowski J, Wilimski R, Raiter A, Szymanowska A, Jassem J: The influence of blood transfusion on survival in operated non-small cell lung cancer patients. J Thorac Cardiovasc Surg 2003; 126:755-760
7. Sandrelli L, Pardini A, Lorusso R, Sala ML, Licenziati M, Alfieri O: Impact of autologous blood predonation on a comprehensive blood conservation program. Ann Thorac Surg 1995; 59:730-755

Observational studies, case reports, or non-pertinent comparison groups

1. Billote DB, Glisson SN, Green D, Wixson RL: A prospective, randomized study of preoperative autologous donation for hip replacement surgery. J Bone Joint Surg Am 2002; 84-A:1299-1304
2. Billote DB, Glisson SN, Green D, Wixson RL: Efficacy of preoperative autologous blood donation: analysis of blood loss and transfusion practice in total hip replacement. J Clin Anesth 2000; 12:537-542
3. Benavides S, Nicol K, Koranyi K, Nahata MC: Yersinia septic shock following an autologous transfusion in a pediatric patient. Transfus Apher Sci 2003; 28:19-23
4. Bhatt K, Cherian S, Agarwal R, Jose S, Cherian KM: Perioperative management of sickle cell disease in paediatric cardiac surgery. Anaesth Intensive Care 2007; 35:792-795
5. Bottner F, Pavone V, Johnson T, Heitkemper S, Sculco TP: Blood management after bilateral total knee arthroplasty. Clin Orthop 2003; 410:254-261
6. Chan ACW, Blumgart LH, Wuest DL, Melendez JA, Fong Y: Use of preoperative autologous blood donation in liver resections for colorectal metastases. Am J Surg 1998; 175:461-465
7. Clugston PA, Fitzpatrick DG, Kester DA, Folet B, Germann E: Autologous blood use in reduction mammaplasty: is it justified? Plast Reconstr Surg 1995; 95:824-828
8. Etchason J, Petz L, Keeler E, Calhoun L, Kleinman S, Snider C, Fink A, Brook R: The cost effectiveness of preoperative autologous blood donations. N Engl J Med 1995; 332:719-724
9. Goh M, Kleer CG, Kielczewski P, Wojno KJ, Kim K, Oesterling JE: Autologous blood donation prior to anatomical radical retropubic prostatectomy: is it necessary? Urology 1997; 49:569-573
10. Kasper SM, Giesecke T, Limpers P, Sabatowski R, Mehlhorn U, Diefenbach C: Failure of autologous fresh frozen plasma to reduce blood loss and transfusion requirements in coronary artery bypass surgery. Anesthesiology 2001; 95:81-86
11. Yokomuro M, Ebine K, Shiroma K, Tamura S, Kumabe S, Ohtuki M, Suzuki H, Uchida S: Safety and efficacy of autologous platelet transfusion in cardiac surgery: comparison of cryopreservation, blood collection on the day before surgery, and blood collection during surgery. Cryobiology 1999; 38:236-242

PAD versus preprocedure acute normovolemic hemodilution (ANH):

Nonrandomized comparative studies

1. Terada N, Arai Y, Matsuta Y, Maekawa S, Okubo K, Ogura K, Matsuda N, Yonei A: Acute normovolemic hemodilution for radical prostatectomy: can it replace preoperative autologous blood transfusion? Int J Urol 2001; 8:149-152

PAD versus intraoperative or postoperative blood recovery:

Randomized controlled trials

1. Waters JH, Lee JS, Klein E, O'Hara J, Zippe C, Potter PS: Preoperative autologous donation versus cell salvage in the avoidance of allogeneic transfusion in patients undergoing radical retropubic prostatectomy. Anesth Analg 2004 ;98:537-542

Nonrandomized comparative studies

1. Gray CL, Amling CL, Polston GR, Powell CR, Kane CJ: Intraoperative cell salvage in radical retropubic prostatectomy. Urology 2001; 58:740-745
2. MacIvor D, Nelson J, Triulzi D: Impact of intraoperative red blood cell salvage on transfusion requirements and outcomes in radical prostatectomy. Transfusion 2009; 49:1431-1434
3. O'Hara PJ, Hertzer NR, Krajewski LP, Cox GS, Beven EG: Reduction in the homologous blood requirement for abdominal aortic aneurysm repair by the use of preadmission autologous blood donation. Surgery 1994; 115:69-76

III. Preprocedure patient preparation

Reversal of anticoagulants.

Prothrombin complex concentrates (PCC): Bebulin, Profilnin, Kcentra:

Observational studies, case reports, or non-pertinent comparison groups

1. Hanke AA, Joch C, Görlinger K: Long-term safety and efficacy of a pasteurized nanofiltrated prothrombin complex concentrate (Beriplex P/N): a pharmacovigilance study. Br J Anaesth 2013; 110:764-772
2. Schick KS, Fertmann JM, Jauch KW, Hoffmann JN: Prothrombin complex concentrate in surgical patients: retrospective evaluation of vitamin K antagonist reversal and treatment of severe bleeding. Crit Care 2009; 13:R191
3. Wong Y: Use of prothrombin complex concentrate for vitamin K antagonist reversal before surgical treatment of intracranial hemorrhage. Clin Med Insights Case Rep 2011; 4:1-6

Vitamin K:

Nonrandomized comparative studies

1. Barnette RE, Wendling WW, Schweiger JW, Brister NW, Schartel SA, Chen D, Shuman CA, McClurken JB, Jeevanandam V: Intravenous vitamin K1 prior to orthotopic heart transplantation: effects in vivo and in vitro. Acta Anaesthesiol Scand 1997; 41:78-83

Antifibrinolytics for prophylaxis of excessive bleeding.

ε-Aminocaproic acid:

Randomized controlled trials; ε-aminocaproic acid vs placebo:

1. Amar D, Grant FM, Zhang H, Boland PJ, Leung DH, Healey JA: Antifibrinolytic therapy and perioperative blood loss in cancer patients undergoing major orthopedic surgery. Anesthesiology 2003; 98:337-342

2. Camarasa MA, Ollé G, Serra-Prat M, Martín A, Sánchez M, Ricós P, Pérez A, Opisso L: Efficacy of aminocaproic, tranexamic acids in the control of bleeding during total knee replacement: a randomized clinical trial. Br J Anaesth 2006; 96:576-582
3. Daily PO, Lamphere JA, Dembitsky WP, Adamson RM, Dans NF: Effect of prophylactic epsilon-aminocaproic acid on blood loss and transfusion requirements in patients undergoing first-time coronary artery bypass grafting. A randomized, prospective, double-blind study. J Thorac Cardiovasc Surg 1994; 108:99-106
4. Dalmau A, Sabate A, Acosta F, Garcia-Huete L, Koo M, Sansano T, Rafecas A, Figueras J, Jaurrieta E, Parrilla P: Tranexamic acid reduces red cell transfusion better than epsilon-aminocaproic acid or placebo in liver transplantation. Anesth Analg 2000; 91:29-34
5. Florentino-Pineda I, Thompson GH, Poe-Kochert C, Huang RP, Haber LL, Blakemore LC: The effect of Amicar on perioperative blood loss in idiopathic scoliosis: The results of a prospective, randomized double-blind study. Spine 2004; 29:233-238
6. Hardy JF, Belisle S, Dupont C, Harel F, Robitaille D, Roy M, Gagnon L: Prophylactic tranexamic acid and epsilon-aminocaproic acid for primary myocardial revascularization. Ann Thorac Surg 1998; 65:371-376
7. Harley BJ, Beaupre LA, Jones CA, Cinats JG, Guenther CR: The effect of epsilon aminocaproic acid on blood loss in patients who undergo primary total hip replacement: a pilot study. Can J Surg 2002; 45:185-190
8. Kikura M, Levy JH, Tanaka KA, Ramsay JG: A double-blind, placebo-controlled trial of epsilon-aminocaproic acid for reducing blood loss in coronary artery bypass grafting surgery. J Am Coll Surg 2006; 202:216-222
9. Kluger R, Olive DJ, Stewart AB, Blyth CM: Epsilon-aminocaproic acid in coronary artery bypass graft surgery: preincision or postheparin? Anesthesiology 2003; 99:1263-1269
10. Menichetti A, Tritapepe L, Ruvolo G, Speziale G, Cogliati A, Di Giovanni C, Pacilli M, Criniti A: Changes in coagulation patterns, blood loss and blood use after cardiopulmonary bypass: aprotinin vs tranexamic acid vs epsilon aminocaproic acid. J Cardiovasc Surg 1996; 37:401-407
11. Ray M, Hatcher S, Whitehouse SL, Crawford S, Crawford R: Aprotinin and epsilon aminocaproic acid are effective in reducing blood loss after primary total hip arthroplasty--a prospective randomized double-blind placebo-controlled study. J Thromb Haemost 2005; 3:1421-1427
12. Slaughter TF, Faghih F, Greenberg CS, Leslie JB, Sladen RN: The effects of epsilon-aminocaproic acid on fibrinolysis and thrombin generation during cardiac surgery. Anesth Analg 1997; 85:1221-1226
13. Troianos CA, Sypula RW, Lucas DM, D'Amico F, Mathie TB, Desai M, Pasqual RT, Pellegrini RV, Newfeld ML: The effect of prophylactic epsilon-aminocaproic acid on bleeding, transfusions, platelet function, and fibrinolysis during coronary artery bypass grafting. Anesthesiology 1999; 91:430-435

Randomized controlled trials; ε-aminocaproic acid vs no antifibrinolytic therapy:

1. Penta de Peppo A, Pierri MD, Scafuri A, De Paulis R, Colantuono G, Caprara E, Tomai F, Chiariello L: Intraoperative antifibrinolysis and blood-saving techniques in cardiac surgery. Prospective trial of 3 antifibrinolytic drugs. Tex Heart Inst J 1995; 22:231-236
2. Urban MK, Beckman J, Gordon M, Urquhart B, Boachie-Adjei O: The efficacy of antifibrinolytics in the reduction of blood loss during complex adult reconstructive spine surgery. Spine 2001; 26:1152-1156

Nonrandomized comparative studies:

1. Florentino-Pineda I, Blakemore LC, Thompson GH, Poe-Kochert C, Adler P, Tripi P: The Effect of ε-aminocaproic acid on perioperative blood loss in patients with idiopathic scoliosis undergoing posterior spinal fusion: a preliminary prospective study. Spine 2001; 26:1147-1151
2. Jordan D, Delphin E, Rose E: Prophylactic epsilon-aminocaproic acid (EACA) administration minimizes blood replacement therapy during cardiac surgery. Anesth Analg 1995; 80:827-829

Observational studies, case reports, or non-pertinent comparison groups:

1. Bennett-Guerrero E, Sorohan JG, Canada AT, Ayuso L, Newman MF, Reves JG, Mythen MG: ε-aminocaproic acid plasma levels during cardiopulmonary bypass. Anesth Analg 1997; 85:248-251
2. Mangano DT, Tudor IC, Dietzel C: The risk associated with aprotinin in cardiac surgery. N Eng J Med 2006; 354:353-365

Tranexamic acid:

Randomized controlled trials; tranexamic acid vs placebo:

1. Ahn SW, Shim JK, Youn YN, Song JW, Yang SY, Chung SC, Kwak YL: Effect of tranexamic acid on transfusion requirement in dual antiplatelet-treated anemic patients undergoing off-pump coronary artery bypass graft surgery. Circ J 2012; 76:96-101
2. Andreasen JJ, Nielsen C: Prophylactic tranexamic acid in elective, primary coronary artery bypass surgery using cardiopulmonary bypass. Eur J Cardiothorac Surg 2004; 26:311-317
3. Benoni G, Fredin H: Fibrinolytic inhibition with tranexamic acid reduces blood loss and blood transfusion after knee arthroplasty: a prospective, randomised, double-blind study of 86 patients. J Bone Joint Surg Br 1996; 78:434-440
4. Benoni G, Lethagen S, Nilsson P, Fredin H: Tranexamic acid, given at the end of the operation, does not reduce postoperative blood loss in hip arthroplasty. Acta Orthop Scand 2000; 71:250-254
5. Boylan JF, Klinck JR, Sandler AN, Arellano R, Greig PD, Nierenberg H, Roger SL, Glynn MF: Tranexamic acid reduces blood loss, transfusion requirements, and coagulation factor use in primary orthotopic liver transplantation. Anesthesiology 1996; 85:1043-1048
6. Brown RS, Thwaites BK, Mongan PD: Tranexamic acid is effective in decreasing postoperative bleeding and transfusions in primary coronary artery bypass operations: a double-blind, randomized, placebo-controlled trial. Anesth Analg 1997; 85:963-970
7. Caglar GS, Tasci Y, Kayikcioglu F, Haberal A: Intravenous tranexamic acid use in myomectomy: a prospective randomized double-blind placebo controlled study. Eur J Obstet Gynecol Reprod Biol 2008; 137:227-231
8. Camarasa MA, Ollé G, Serra-Prat M, Martín A, Sánchez M, Ricós P, Pérez A, Opisso L: Efficacy of aminocaproic, tranexamic acids in the control of bleeding during total knee replacement: a randomized clinical trial. Br J Anaesth 2006; 96:576-582
9. Casati V, Bellotti F, Gerli C, Franco A, Oppizzi M, Cossolini M, Calori G, Benussi S, Alfieri O, Torri G: Tranexamic acid administration after cardiac surgery: A prospective, randomized, double-blind, placebo-controlled study. Anesthesiology 2001; 94:8-14

10. Casati V, Della Valle P, Benussi S, Franco A, Gerli C, Baili P, Alfieri O, D'Angelo A: Effects of tranexamic acid on postoperative bleeding and related hematochemical variables in coronary surgery: comparison between on-pump and off-pump techniques. J Thorac Cardiovasc Surg 2004; 128:83-91
11. Casati V, Gerli C, Franco A, Torri G, D'Angelo A, Benussi S, Alfieri O: Tranexamic acid in off-pump coronary surgery: A preliminary, randomized, double-blind, placebo-controlled study. Ann Thorac Surg 2001; 72:470-475
12. Casati V, Sandrelli L, Speziali G, Calori G, Grasso MA, Spagnolo S: Hemostatic effects of tranexamic acid in elective thoracic aortic surgery: a propective randomized, double-blinded, placebo-controlled study. J Thorac Cardiovasc Surg 2002; 123:1084-1091
13. Choi WS, Irwin MG, Samman N: The effect of tranexamic acid on blood loss during orthognathic surgery: a randomized controlled trial. J Oral Maxillofac Surg 2009; 67:125-133
14. Claeys MA, Vermeersch N, Haentjens P: Reduction of blood loss with tranexamic acid in primary total hip replacement surgery. Acta Chir Belg 2007; 107:397-401
15. Coffey A, Pittmam J, Halbrook H, Fehrenbacher J, Beckman D, Hormuth D: The use of tranexamic acid to reduce postoperative bleeding following cardiac surgery: a double-blind randomized trial. Am Surg 1995; 61:566-568
16. Crescenti A, Borghi G, Bignami E, Bertarelli G, Landoni G, Casiraghi GM, Briganti A, Montorsi F, Rigatti P, Zangrillo A: Intraoperative use of tranexamic acid to reduce transfusion rate in patients undergoing radical retropubic prostatectomy: double blind, randomised, placebo controlled trial. BMJ 2011; 343:d5701. doi
17. Dalmau A, Sabate A, Acosta F, Garcia-Huete L, Koo M, Sansano T, Rafecas A, Figueras J, Jaurrieta E, Parrilla P: Tranexamic acid reduces red cell transfusion better than epsilon-aminocaproic acid or placebo in liver transplantation. Anesth Analg 2000; 91:29-34
18. Dryden PJ, O'Connor JP, Jamieson WR, Reid I, Ansley D, Sadeghi H, Burr LH, Munro AI, Merrick PM: Tranexamic acid reduces blood loss and transfusion in reoperative cardiac surgery. Can J Anaesth 1997; 44:934-941
19. Ekback G, Axelsson K, Ryttberg L, Edlund B, Kjellberg J, Weckstrom J, Carlsson O, Schott U: Tranexamic acid reduces blood loss in total hip replacement surgery. Anesth Analg 2000; 91:1124-1130
20. Engel JM, Hohaus T, Ruwoldt R, Menges T, Jurgensen I, Hempelmann G: Regional hemostatic status and blood requirements after total knee arthroplasty with and without tranexamic acid or aprotinin. Anesth Analg 2001; 92:775-780
21. Goobie SM, Meier PM, Pereira LM, McGowan FX, Prescilla RP, Scharp LA, Rogers GF, Proctor MR, Meara JG, Soriano SG, Zurakowski D, Sethna NF: Efficacy of tranexamic acid in pediatric craniosynostosis surgery: a double-blind, placebo-controlled trial. Anesthesiology 2011; 114:862-871
22. Good L, Peterson E, Lisander B: Tranexamic acid decreases external blood loss but not hidden blood loss in total knee replacement. Br J Anaesth 2003; 90:596-599
23. Hardy JF, Belisle S, Dupont C, Harel F, Robitaille D, Roy M, Gagnon L: Prophylactic tranexamic acid and epsilon-aminocaproic acid for primary myocardial revascularization. Ann Thorac Surg 1998; 65:371-376
24. Hiippala S, Strid L, Wennerstrand M, Arvela V, Mantyla S, Ylinen J, Niemela H: Tranexamic acid (Cyklokapron) reduces perioperative blood loss associated with total knee arthroplasty. Br J Anaesth 1995; 74:534-537
25. Hiippala ST, Strid LJ, Wennerstrand MI, Arvela JV, Niemela HM, Mantyla SK, Kuisma RP, Ylinen JE: Tranexamic acid radically decreases blood loss and transfusions associated with total knee arthroplasty. Anesth Analg 1997; 84:839-844

26. Husted H, Blond L, Sonne-Holm S, Holm G, Jacobsen TW, Gebuhr P: Tranexamic acid reduces blood loss and blood transfusions in primary total hip arthroplasty: a prospective randomized double-blind study in 40 patients. Acta Orthop Scand 2003; 74:665-669
27. Jansen AJ, Andreica S, Claeys M, D'Haese J, Camu F, Jochmans K: Use of tranexamic acid for an effective blood conservation strategy after total knee arthroplasty. Br J Anaesth 1999; 83:596-601
28. Karski JM, Teasdale SJ, Norman P, Carroll J, VanKessel K, Wong P, Glynn MF: Prevention of bleeding after cardiopulmonary bypass with high-dose tranexamic acid. Double-blind, randomized clinical trial. J Thorac Cardiovasc Surg 1995; 110:835-842
29. Kaspar M, Ramsay MA, Nguyen AT, Cogswell M, Hurst G, Ramsay KJ: Continuous small-dose tranexamic acid reduces fibrinolysis but not transfusion requirements during orthotopic liver transplantation. Anesth Analg 1997; 85:281-285
30. Katsaros D, Petricevic M, Snow NJ, Woodhall DD, Van Bergen R: Tranexamic acid reduces postbypass blood use: a double-blinded, prospective, randomized study of 210 patients. Ann Thorac Surg 1996; 61:1131-1135
31. Lemay E, Guay J, Cote C, Roy A: Tranexamic acid reduces the need for allogenic red blood cell transfusions in patients undergoing total hip replacement. Can J Anaesth 2004; 51:31-37
32. Lin PC, Hsu CH, Huang CC, Chen WS, Wang JW: The blood-saving effect of tranexamic acid in minimally invasive total knee replacement: is an additional pre-operative injection effective? J Bone Joint Surg Br 2012; 94:932-936
33. Maniar RN, Kumar G, Singhi T, Nayak RM, Maniar PR: Most effective regimen of tranexamic acid in knee arthroplasty: a prospective randomized controlled study in 240 patients. Clin Orthop Relat Res 2012; 470:2605-2612
34. Menichetti A, Tritapepe L, Ruvolo G, Speziale G, Cogliati A, Di Giovanni C, Pacilli M, Criniti A: Changes in coagulation patterns, blood loss and blood use after cardiopulmonary bypass: aprotinin vs tranexamic acid vs epsilon aminocaproic acid. J Cardiovasc Surg 1996; 37:401-407
35. Mongan PD, Brown RS, Thwaites BK: Tranexamic acid and aprotinin reduce postoperative bleeding and transfusions during primary coronary revascularization. Anesth Analg 1998; 87:258-265
36. Murphy GJ, Mango E, Lucchetti V, Battaglia F, Catapano D, Rogers CA, Angelini GD: A randomized trial of tranexamic acid in combination with cell salvage plus a meta-analysis of randomized trials evaluating tranexamic acid in off-pump coronary artery bypass grafting. J Thorac Cardiovasc Surg 2006; 132:475-480
37. Neilipovitz DT, Murto K, Hall L, Barrowman NJ, Splinter WM: A randomized trial of tranexamic acid to reduce blood transfusion for scoliosis surgery. Anesth Analg 2001; 93:82-87
38. Nuttall GA, Oliver WC, Ereth MH, Santrach PJ, Bryant SC, Orszulak TA, Schaff HV: Comparison of blood-conservation strategies in cardiac surgery patients at high risk for bleeding. Anesthesiology 2000; 92:674-682
39. Orpen NM, Little C, Walker G, Crawfurd EJ: Tranexamic acid reduces early post-operative blood loss after total knee arthroplasty: a prospective randomized controlled trial of 29 patients. Knee 2006; 13:106-110
40. Pleym H, Stenseth R, Wahba A, Bjella L, Karevold A, Dale O: Single-dose tranexamic acid reduces postoperative bleeding after coronary surgery in patients treated with aspirin until surgery. Anesth Analg 2003; 96:923-928

41. Pugh SC, Wielogorski AK: A comparison of the effects of tranexamic acid and low-dose aprotinin on blood loss and homologous blood usage in patients undergoing cardiac surgery. J Cardiothorac Vasc Anesth 1995; 9:240-244
42. Shore-Lesserson L, Reich DL, Vela-Cantos F, Ammar T, Ergin MA: Tranexamic acid reduces transfusions and mediastinal drainage in repeat cardiac surgery. Anesth Analg 1996; 83:18-26
43. Taghaddomi RJ, Mirzaee A, Attar AS, Shirdel A: Tranexamic acid reduces blood loss in off-pump coronary artery bypass surgery. J Cardiothorac Vasc Anesth 2009; 23:312-315
44. Tanaka N, Sakahashi H, Sato E, Hirose K, Ishima T, Ishii S: Timing of the administration of tranexamic acid for maximum reduction in blood loss in arthroplasty of the knee. J Bone Jt Surg Br 2001; 83:702-705
45. Vanek T, Jares M, Fajt R, Straka Z, Jirasek K, Kolesar M, Brucek P, Maly M: Fibrinolytic inhibitors in off-pump coronary surgery: a prospective, randomized, double-blind TAP study (tranexamic acid, aprotinin, placebo). Eur J Cardiothorac Surg 2005; 28:563-568
46. Wei M, Jian K, Guo Z, Wang L, Jiang D, Zhang L, Tarkka M: Tranexamic acid reduces postoperative bleeding in off-pump coronary artery bypass grafting. Scand Cardiovasc J 2006; 40:105-109
47. Wu CC, Ho WM, Cheng SB, Yeh DC, Wen MC, Liu TJ, P'eng FK: Perioperative parenteral tranexamic acid in liver tumor resection: a prospective randomized trial toward a "blood transfusion"-free hepatectomy. Ann Surg 2006; 243:173-180
48. Yamasaki S, Masuhara K, Fuji T: Tranexamic acid reduces blood loss after cementless total hip arthroplasty: Prospective randomized study in 40 cases. Int Orthop 2004; 28:69-73
49. Zabeeda D, Medalion B, Sverdlov M, Ezra S, Schachner A, Ezri T, Cohen AJ: Tranexamic acid reduces bleeding and the need for blood transfusion in primary myocardial revascularization. Ann Thorac Surg 2002; 74:733-738
50. Zufferey PJ, Miquet M, Quenet S, Martin P, Adam P, Albaladejo P, Mismetti P, Molliex S: Tranexamic acid in hip fracture surgery: a randomized controlled trial. Br J Anaesth 2010; 104:23-30

Randomized controlled trials; tranexamic acid vs no antifibrinolytic therapy:

1. Blauhut B, Harringer W, Bettelheim P, Doran JE, Spath P, Lundsgaard-Hansen P: Comparison of the effects of aprotinin and tranexamic acid on blood loss and related variables after cardiopulmonary bypass. J Thorac Cardiovasc Surg 1994; 108:1083-1091
2. Jares M, Vanek T, Straka Z, Brucek P: Tranexamic acid reduces bleeding after off-pump coronary artery bypass grafting. J Cardiovasc Surg 2003; 44:205-208
3. McConnell JS, Shewale S, Munro NA, Shah K, Deakin AH, Kinninmonth AW: Reduction of blood loss in primary hip arthroplasty with tranexamic acid or fibrin spray. Acta Orthop 2011; 82:660-663
4. Penta de Peppo A, Pierri MD, Scafuri A, De Paulis R, Colantuono G, Caprara E, Tomai F, Chiariello L: Intraoperative antifibrinolysis and blood-saving techniques in cardiac surgery. Prospective trial of 3 antifibrinolytic drugs. Tex Heart Inst J 1995; 22:231-236
5. Veien M, Sorensen JV, Madsen F, Juelsgaard P: Tranexamic acid given intraoperatively reduces blood loss after total knee replacement: a randomized, controlled study. Acta Anaesthesiol Scand 2002; 46:1206-1211

Nonrandomized comparative studies:

1. Clavé A, Fazilleau F, Dumser D, Lacroix J: Efficacy of tranexamic acid on blood loss after primary cementless total hip replacement with rivaroxaban thromboprophylaxis: A case-control study in 70 patients. Orthop Traumatol Surg Res 2012; 98:484-490
2. Connelly NR, Kiessling BM, Brull SJ: Does tranexamic acid decrease bleeding in patients undergoing cardiopulmonary bypass? Yale J Biol Med 1994; 67:265-268
3. Hynes M, Calder P, Scott G: The use of tranexamic acid to reduce blood loss during total knee arthroplasty. Knee 2003; 10:375-377
4. Lin PC, Hsu CH, Chen WS, Wang JW: Does tranexamic acid save blood in minimally invasive total knee arthroplasty? Clin Orthop Relat Res 2011; 469:1995-2002
5. Lozano M, Basora M, Peidro L, Merino I, Segur JM, Pereira A, Salazar F, Cid J, Lozano L, Mazzara R, Macule F: Effectiveness and safety of tranexamic acid administration during total knee arthroplasty. Vox Sang 2008; 95:39-44
6. Rousou JA, Engelman RM, Flack JE 3rd, Deaton DW, Owen SG: Tranexamic acid significantly reduces blood loss associated with coronary revascularization. Ann Thorac Surg 1995; 59:671-675
7. Singh J, Ballal MS, Mitchell P, Denn PG: Effects of tranexamic acid on blood loss during total hip arthroplasty. J Orthop Surg (Hong Kong) 2010; 18:282-286

Observational studies, case reports, or non-pertinent comparison groups:

1. Bokesch PM, Szabo G, Wojdyga R, Grocott HP, Smith PK, Mazer CD, Vetticaden S, Wheeler A, Levy JH: A phase 2 prospective, randomized, double-blind trial comparing the effects of tranexamic acid with ecallantide on blood loss from high-risk cardiac surgery with cardiopulmonary bypass (CONSERV-2 Trial). J Thorac Cardiovasc Surg 2012; 143:1022-1029
2. Hekmat K, Zimmermann T, Kampe S, Kasper SM, Weber HJ, Geissler HJ, Mehlhorn U: Impact of tranexamic acid vs. aprotinin on blood loss and transfusion requirements after cardiopulmonary bypass: a prospective, randomised, double-blind trial. Curr Med Res Opin 2004; 20:121-126
3. Ickx BE, van der Linden PJ, Melot C, Wijns W, de Pauw L, Vandestadt J, Hut F, Pradier O: Comparison of the effects of aprotinin and tranexamic acid on blood loss and red blood cell transfusion requirements during the late stages of liver transplantation. Transfusion 2006; 46:595-605
4. Mangano DT, Tudor IC, Dietzel C: The risk associated with aprotinin in cardiac surgery. N Eng J Med 2006; 354:353-365
5. Martin K, Wiesner G, Breuer T, Lange R, Tassani P: The risks of aprotinin and tranexamic acid in cardiac surgery: a one-year follow-up of 1188 consecutive patients. Anesth Analg 2008; 107:1783-1790
6. Rannikko A, Pétas A, Taari K: Tranexamic acid in control of primary hemorrhage during transurethral prostatectomy. Urology 2004; 64:955-958
7. Waldow T, Krutzsch D, Wils M, Plötze K, Matschke K: Low dose aprotinin and low dose tranexamic acid in elective cardiac surgery with cardiopulmonary bypass. Clin Hemorheol Microcirc 2009; 42:269-277

Acute Normovolemic Hemodilution (ANH).

ANH versus no ANH:

Randomized controlled trials:

1. Bennett J, Haynes S, Torella F, Grainger H, McCollum C: Acute normovolemic hemodilution in moderate blood loss surgery: a randomized controlled trial. Transfusion 2006; 46:1097-1103
2. Bennett SR: Perioperative autologous blood transfusion in elective total hip prosthesis operations. Ann R Coll Surg Engl 1994; 76:95-98
3. Boldt J, Weber A, Mailer K, Papsdorf M, Schuster P: Acute normovolaemic haemodilution vs controlled hypotension for reducing the use of allogeneic blood in patients undergoing radical prostatectomy. Br J Anaesth 1999; 82:170-174
4. Fischer M, Matsuo K, Gonen M, Grant F, Dematteo RP, D'Angelica MI, Mascarenhas J, Brennan MF, Allen PJ, Blumgart LH, Jarnagin WR: Relationship between intraoperative fluid administration and perioperative outcome after pancreaticoduodenectomy: results of a prospective randomized trial of acute normovolemic hemodilution compared with standard intraoperative management. Ann Surg 2010; 252:952-958
5. Ford SM, Unsworth-White MJ, Aziz T, Tooze JA, van Besouw JP, Bevan DH, Treasure T: Platelet pheresis is not a useful adjunct to blood-sparing strategies in cardiac surgery. J Cardiothorac Vasc Anesth 2002; 16:321-329
6. Guo JR, Yu J, Jin XJ, Du JM, Guo W, Yuan XH: Effects of acute normovolemic hemodilution on perioperative coagulation and fibrinolysis in elderly patients undergoing hepatic carcinectomy. Chin Med Sci J 2010; 25:146-150
7. Jarnagin WR, Gonen M, Maithel SK, Fong Y, D'Angelica MI, DeMatteo RP, Grant F, Wuest D, Kundu K, Blumgart LH, Fischer M: A prospective randomized trial of acute normovolemic hemodilution compared to standard intraoperative management in patients undergoing major hepatic rescetion. Ann Surg 2008; 248:360-369
8. Kahraman S, Altunkaya H, Celebioglu B, Kanbak M, Pasaoglu I, Erdem K: The effect of acute normovolemic hemodilution on homologous blood requirements and total estimated red blood cell volume lost. Acta Anaesthesiol Scand 1997; 41:614-617
9. Matot I, Scheinin O, Jurim O, Eid A: Effectiveness of acute normovolemic hemodilution to minimize allogeneic blood transfusion in major liver resections. Anesthesiology 2002; 97:794-800
10. Menges T, Wagner RM, Welters I, Ruwoldt R, Boldt J, Hempelmann G: The role of protein C-thrombomodulin system and fibrinolysis during cardiovascular surgery: influence of acute preoperative plasmapheresis. J Cardiothorac Vasc Anesth 1996; 10:482-489
11. Olsfanger D, Fredman B, Goldstein B, Shapiro A, Jedeikin R: Acute normovolaemic haemodilution decreases postoperative allogeneic blood transfusion after total knee replacement. Br J Anaesth 1997; 79:317-321
12. Ramnath AN, Naber HR, de Boer A, Leusink JA: No benefit of intraoperative whole blood sequestration and autotransfusion during coronary artery bypass grafting: results of a randomized clinical trial. J Thorac Cardiovasc Surg 2003; 125:1432-1437
13. Safwat AM, Bush R, Prevec W, Reitan JA: Intraoperative use of platelet-plasmapheresis in vascular surgery. J Clin Anesth 2002; 14:10-14
14. Stover EP, Siegel LC, Hood PA, O'Riordan GE, McKenna TR: Platelet-rich plasma sequestration, with therapeutic platelet yields, reduces allogeneic transfusion in complex cardiac surgery. Anesth Analg 2000; 90:509-516

15. Triulzi DJ, Gilmor GD, Ness PM, Baumgartner WA, Schultheis LW: Efficacy of autologous fresh whole blood or platelet-rich plasma in adult cardiac surgery. Transfusion 1995; 35:627-634
16. Wajon P, Gibson J, Calcroft R, Hughes C, Thrift B: Intraoperative plateletpheresis and autologous platelet gel do not reduce chest tube drainage or allogeneic blood transfusion after reoperative coronary artery bypass graft. Anesth Analg 2001; 93:536-542
17. Weber CF, Jámbor C, Strasser C, Moritz A, Papadopoulos N, Zacharowski K, Meininger D: Normovolemic modified ultrafiltration is associated with better preserved platelet function and less postoperative blood loss in patients undergoing complex cardiac surgery: a randomized and controlled study. J Thorac Cardiovasc Surg 2011; 141:1298-1304

Nonrandomized comparative studies:

1. Canver CC, Kroncke GM, Nichols RD, Murray EL, Mentzer RM Jr: The effects of intraoperative autologous whole blood sequestration on the need for transfusion of allogenic blood and blood products in coronary bypass operations. J Cardiovasc Surg (Torino) 1995; 36:423-438
2. Cina CS, It SC, Clase CM, Bruin G: A cohort study of coagulation parameters and the use of blood products in surgery of the thoracic and thoracoabdominal aorta. J Vasc Surg 2001; 33:462-468
3. Giurati G, Zanetta G, Caspani L, Landon F, Pellegrino A, Baglioni S, Mangioni C: Autologous blood transfusion in patients undergoing radical hysterectomy. Br J Obstet Gynaecol 1995; 102:64-65
4. Hobisch-Hagen P, Schobersberger W, Falkensammer J, Luz G, Innerhofer P, Frischhut B, Puschendorf B, Mair J: No release of cardiac troponin I during major orthopedic surgery after acute normovolemic hemodilution. Acta Anaesthesiol Scand 1998; 42:799-804
5. Johnson LB, Plotkin JS, Kuo PC: Reduced transfusion requirements during major hepatic resection with use of intraoperative isovolemic hemodilution. Am J Surg 1998; 176:608-611
6. Pellegrino A, Landoni F, Cormio G, Ferrando P, Lissoni A, Scalambrino S, Mangioni C: Effectiveness of autologous blood transfusion in patients undergoing radical hysterectomy. Ann Chir Gynaecol 1995; 84:391-394
7. Schmied H, Schiferer A, Sessler DI, Meznik C: The effects of red-cell scavenging, hemodilution, and active warming on allogenic blood requirements in patients undergoing hip or knee arthroplasty. Anesth Analg 1998; 86:387-391
8. Wolowczyk L, Lewis DR, Nevin M, Smith FC, Baird RN, Lamont PM: The effect of acute normovolaemic haemodilution on blood transfusion requirements in abdominal aortic aneurysm repair. Eur J Vasc Endovasc Surg 2001; 22:361-364

Observational studies, case reports, or non-pertinent comparison groups:

1. Almeida MF: Preoperative normovolemic hemodilution in aesthetic plastic surgery. Aesthetic Plast Surg 1999; 23:445-449
2. Amanor-Boadu SD, Malomo A, Komolafe EO, Adeolu AA, Abdullahi A, Shokunbi MT: Acute isovolaemic haemodilution in two Jehovah's Witnesses presenting for major intracranial surgery. Afr J Med Sci 2002; 31:79-81
3. Cina CS, Bruin G: Acute normovolemic hemodilution (ANH) in surgery of the thoraco-abdominal aorta. A cohort study to evaluate coagulation parameters and blood products utilization. J Cardiovasc Surg 1999; 40:37-43

4. Estella NM, Berry DL, Baker BW, Wali AT, Belfort MA: Normovolemic hemodilution before cesarean hysterectomy for placenta percreta. Obstet Gynecol 1997; 90:669-670
5. Ferraz-Neto BH, Silva ED, Afonso RC, Gregory FH, Meira-Filho SP, Macedo CP, Parra OM, Leitao RM, Saad WA: Acute normovolemic intraoperative hemodilution in liver transplantation. Transplant Proc 1999; 31:3069-3070
6. Loubser PG: Use of acute normovolemic hemodilution for blood conservation during off-pump coronary artery bypass surgery. Can J Anaesth 2003; 50:620-621
7. Herregods L, Moerman A, Foubert L, Den Blauwen N, Mortier E, Poelaert J, Struys M: Limited intentional normovolemic hemodilution: ST-segment changes and use of homologous blood products in patients with left main coronary artery stenosis. J Cardiothorac Vasc Anesth 1997; 11:18-23
8. Mackay Z, Shugufta Q, Din M, Guru AA: Hemodilution in complicated high velocity vascular injuries of limbs. J Cardiovasc Surg 1996; 37:217-221
9. Monk TG, Goodnough LT, Brecher ME, Pulley DD, Colberg JW, Andriole GL, Catalona WJ: Acute normovolemic hemodilution can replace preoperative autologous blood donation as a standard of care for autologous blood procurement in radical prostatectomy. Anesth Analg 1997; 85:953-958
10. Rehm M, Orth V, Kreimeier U, Thiel M, Haller M, Brechtelsbauer H, Finsterer U: Changes in intravascular volume during acute normovolemic hemodilution and intraoperative retransfusion in patients with radical hysterectomy. Anesthesiology 2000; 92:657-664
11. Terada N, Arai Y, Matsuta Y, Maekawa S, Okubo K, Ogura K, Matsuda N, Yonei A: Acute normovolemic hemodilution for radical prostatectomy: can it replace preoperative autologous blood transfusion? Int J Urol 2001; 8:149-152
12. Terai A, Terada N, Yoshimura K, Ichioka K, Ueda N, Utsunomiya N, Kohei N, Arai Y, Yonei A: Use of acute normovolemic hemodilution in patients undergoing radical prostatectomy. Urology 2005; 65:1152-1156

ANH combined with intraoperative blood recovery (ICSB) versus either ANH or ISCB:

Randomized controlled trials:

1. Bacher A, Mayer N, Rajek AM, Haider W: Acute normovolaemic haemodilution does not aggravate gastric mucosal acidosis during cardiac surgery. Intensive Care Med 1998; 24:313-321
2. Blais RE, Hadjipavlou AG, Shulman G: Efficacy of autotransfusion in spine surgery: comparison of autotransfusion alone and with hemodilution and apheresis. Spine 1996; 21:2795-2800
3. Casati V, Speziali G, D'Alessandro C, Cianchi C, Antonietta Grasso M, Spagnolo S, Sandrelli L: Intraoperative low-volume acute normovolemic hemodilution in adult open-heart surgery. Anesthesiology 2002; 97:367-373
4. Haynes SL, Torella F, Wong JC, Dalrymple K, James M, McCollum CN: Economic evaluation of a randomized clinical trial of haemodilution with cell salvage in aortic surgery. Br J Surg 2002; 89:731-736
5. Helm RE, Klemperer JD, Rosengart TK, Gold JP, Peterson P, DeBois W, Altorki NK, Lang S, Thomas S, Isom OW, Krieger KH: Intraoperative autologous blood donation preserves red cell mass but does not decrease postoperative bleeding. Ann Thorac Surg 1996; 62:1431-1441
6. Hohn L, Schweizer A, Licker M, Morel DR: Absence of beneficial effect of acute normovolemic hemodilution combined with aprotinin on allogeneic blood transfusion requirements in cardiac surgery. Anesthesiology 2002; 96:276-282

7. Kochamba GS, Pfeffer TA, Sintek CF, Khonsari S: Intraoperative autotransfusion reduces blood loss after cardiopulmonary bypass. Ann Thorac Surg 1996; 61:900-903
8. Licker M, Sierra J, Kalangos A, Panos A, Diaper J, Ellenberger C: Cardioprotective effects of acute normovolemic hemodilution in patients with severe aortic stenosis undergoing valve replacement. Transfusion 2007; 47:341-350
9. Lisander B, Jonsson R, Nordwall A: Combination of blood-saving methods decreases homologous blood requirements in scoliosis surgery. Anaesth Intensive Care 1996; 24:555-558
10. McGill N, O'Shaughnessy D, Pickering R, Herbertson M, Gill R: Mechanical methods of reducing blood transfusion in cardiac surgery: randomised controlled trial. BMJ 2002; 324:1299-303
11. Shore-Lesserson L, Reich DL, DePerio M, Silvay G: Autologous platelet-rich plasmapheresis: risk versus benefit in repeat cardiac operations. Anesth Analg 1995; 81:229-235
12. Shulman G, Solanki DR, Hadjipavlou A: Augmented autologous transfusions in major reconstructive spine surgery. J Clin Apheresis 1998; 13:62-68
13. Wolowczyk L, Nevin M, Smith FC, Baird RN, Lamont PM: Haemodilutional effect of standard fluid management limits the effectiveness of acute normovolaemic haemodilution in AAA surgery--results of a pilot trial. Eur J Vasc Endovasc Surg 2003; 26:405-411
14. Wong JC, Torella F, Haynes SL, Dalrymple K, Mortimer AJ, McCollum CN; ATIS Investigators: Autologous versus allogeneic transfusion in aortic surgery: a multicenter randomized clinical trial. Ann Surg 2002; 235:145-151

Nonrandomized comparative studies

1. Copley LA, Richards BS, Safavi FZ, Newton PO: Hemodilution as a method to reduce transfusion requirements in adolescent spine fusion surgery. Spine 1999; 24:219-222
2. Shulman G, Grecula MJ, Hadjipavlou AG: Intraoperative autotransfusion in hip arthroplasty. Clin Orthop 2002; 396:119-30

IV. Intraoperative and postoperative interventions

Blood management protocols.

Multimodal protocols or algorithms:

Randomized controlled trials: general or point-of-care protocols or algorithms:

1. Capraro L, Kuitunen A, Salmenpera M, Kekomaki R: On-site coagulation monitoring does not affect hemostatic outcome after cardiac surgery. Acta Anaesthesiologica Scand 2001; 45:200-206
2. Nuttall GA, Oliver WC, Santrach PJ, Bryant S, Dearani JA, Schaff HV, Ereth MH: Efficacy of a simple intraoperative transfusion algorithm for nonerythrocyte component utilization after cardiopulmonary bypass. Anesthesiology 2001; 94:773-781
3. Wong CJ, Vandervoort MK, Vandervoort SL, Donner A, Zou G, MacDonald JK, Freedman J, Karkouti K, MacDonald SJ, Feagan BG: A cluster-randomized controlled trial of a blood conservation algorithm in patients undergoing total hip joint arthroplasty. Transfusion 2007; 47:832-841

Randomized controlled trials; thromboelastrography (TEG) - guided protocols or algorithms:

1. Ak K, Isbir CS, Tetik S, Atalan N, Tekeli A, Aljodi M, Civelek A, Arsan S: Thromboelastography-based transfusion algorithm reduces blood product use after elective CABG: a prospective randomized study. J Card Surg 2009; 24:404-410
2. Royston D, von Kier S: Reduced haemostatic factor transfusion using heparinase-modified thrombelastography during cardiopulmonary bypass. Br J Anaesth 2001; 86:575-578
3. Shore-Lesserson L, Manspeizer HE, DePerio M, Francis S, Vela-Cantos F, Ergin MA: Thromboelastography-guided transfusion algorithm reduces transfusions in complex cardiac surgery. Anesth Analg 1999; 88:312-319

Randomized controlled trials; thromboelastrography (TEG) - guided protocols or algorithms:

1. Schaden E, Kimberger O, Kraincuk P, Baron DM, Metnitz PG, Kozek-Langenecker S: Perioperative treatment algorithm for bleeding burn patients reduces allogeneic blood product requirements. Br J Anaesth 2012; 109:376-381

Nonrandomized comparative studies:

1. Avidan MS, Alcock EL, Da Fonseca J, Ponte J, Desai JB, Despotis GJ, Hunt BJ: Comparison of structured use of routine laboratory tests or near-patient assessment with clinical judgement in the management of bleeding after cardiac surgery. Br J Anaesth 2004; 92:178-186
2. Gorlinger K, Dirkmann D, Hanke AA, Kamler M, Kottenberg E, Thielmann M, Jakob H, Peters J: First-line therapy with coagulation factor concentrates combined with point-of-care coagulation testing is associated with decreased allogeneic blood transfusion in cardiovascular surgery: A retrospective, single-center cohort study. Anesthesiology 2011; 115:1179-1191
3. Martinez V, Monsaingeon-Lion A, Cherif K, Judet T, Chauvin M, Fletcher D: Transfusion strategy for primary knee and hip arthroplasty: impact of an algorithm to lower transfusion rates and hospital costs. Br J Anaesth 2007; 99:794-800
4. Shields LE, Smalarz K, Reffigee L, Mugg S, Burdumy TJ, Propst M: Comprehensive maternal hemorrhage protocols improve patient safety and reduce utilization of blood products. Am J Obstet Gynecol 2011; 205: 368.e1-368.e8
5. Yaffee DW, Smith DE, Ursomanno PA, Hill FT, Galloway AC, DeAnda A, Grossi EA: Management of blood transfusion in aortic valve surgery: impact of a blood conservation strategy. Ann Thorac Surg 2014; 97:95-101

Observational studies, case reports, or non-pertinent comparison groups:

1. Casati V, D'Angelo A, Barbato L, Turolla D, Villa F, Grasso MA, Porta A, Guerra F: Perioperative management of four anaemic female Jehovah's Witnesses undergoing urgent complex cardiac surgery. Br J Anaesth 2007; 99:349-352
2. Cuenca J, Garcia-Erce JA, Martinez F, Perez-Serrano L, Herrera A, Munoz M: Perioperative intravaneous iron, with or without erythropoietin, plus restrictive transfusion protocol reduce the need for allogeneic blood after knee replacment surgery. Transfusion 2006; 46:1112-1119
3. LaPar DJ, Crosby IK, Ailawadi G, Ad N, Choi E, Spiess BD, Rich JB, Kasirajan V, Fonner E Jr, Kron IL, Speir AM, Investigators for the Virginia Cardiac Surgery Quality

Initiative: Blood product conservation is associated with improved outcomes and reduced costs after cardiac surgery. J Thorac Cardiovasc Surg 2013; 145:796-803
4. Spalding GJ, Hartrumpf M, Sierig T, Oesberg N, Kirschke CG, Albes JM: Cost reduction of perioperative coagulation management in cardiac surgery: value of bedside thrombelastography (ROTEM). Eur J Cardiothorac Surg 2007; 31:1052-1057

Liberal versus restrictive transfusion protocol:

Randomized controlled trials:

1. Bracey AW, Radovancevic R, Riggs SA, Houston S, Cozart H, Vaughn WK, Radovancevic B, McAllister HA, Cooley DA: Lowering the hemoglobin threshold for transfusion in coronary artery bypass procedures: effect on patient outcome. Transfusion 1999; 39:1070-1077
2. Bush RL, Pevec WC, Holcroft JW: A prospective, randomized trial limiting perioperative red blood cell transfusions in vascular patients. Am J Surg 1997; 174:143-148
3. Carson JL, Brooks MM, Abbott JD, Chaitman B, Kelsey SF, Triulzi DJ, Srinivas V, Menegus MA, Marroquin OC, Rao SV, Noveck H, Passano E, Hardison RM, Smitherman T, Vagaonescu T, Wimmer NJ, Williams DO: Liberal versus restrictive transfusion thresholds for patients with symptomatic coronary artery disease. Am Heart J 2013; 165:964-971
4. Carson JL, Terrin ML, Barton FB, Aaaron R, Greenburg AG, Heck DA, Magaziner J, Merlino FE, Bunce G, McClelland B, Duff A, Noveck H: A pilot randomized trial comparing symptomatic vs. hemoglobin-level-driven red blood cell transfusions following hip fracture. Transfusion 1998; 38:522-529
5. Carson JL, Terrin ML, Noveck H, Sanders DW, Chaitman BR, Rhoads GG, Nemo G, Dragert K, Beaupre L, Hildebrand K, Macauley W, Lewis C, Cook DR, Dobbin G, Zakriya KJ, Apple FS, Horney RA, Magaziner J: Liberal or restrictive transfusion in high-risk patients after hip surgery. N Engl J Med 2011; 365:2453-2462
6. Grover M, Talwalkar S, Casbard A, Boralessa H, Contreras M, Boralessa H, Brett S, Goldhill DR, Soni N: Silent myocardial ischaemia and haemoglobin concentration: a randomized controlled trial of transfusion strategy in lower limb arthroplasty. Vox Sang 2006; 90:105-112
7. Hajjar LA, Vincent JL, Galas FR, Nakamura RE, Silva CM, Santos MH, Fukushima J, Kalil Filho R, Sierra DB, Lopes NH, Mauad T, Roquim AC, Sundin MR, Leão WC, Almeida JP, Pomerantzeff PM, Dallan LO, Jatene FB, Stolf NA, Auler JO Jr: Transfusion requirements after cardiac surgery: the TRACS randomized controlled trial. JAMA 2010; 304:1559-1567
8. Johnson RG, Thurer RL, Kruskall MS, Sirois C, Gervino EV, Critchlow J, Weintraub RM: Comparison of two transfusion strategies after elective operations for myocardial revascularization. J Thorac Cardiovasc Surg 1992; 104:307-314
9. So-Osman C, Nelissen R, Te Slaa R, Coene L, Brand R, Brand A: A randomized comparison of transfusion triggers in elective orthopaedic surgery using leucocyte-depleted red blood cells. Vox Sang 2010; 98:56-64

Nonrandomized comparative studies:

1. Cuenca J, Garcia-Erce JA, Martinez F, Cardona R, Perez-Serrano L, Munoz M: Preoperative haematinics and transfusion protocol reduce the need for transfusion after total knee replacement. Int J Surg 2007; 5:89-94

Non-transfusion protocol:

Nonrandomized comparative studies:

1. Harwin SF, Issa K, Naziri Q, Johnson AJ, Mont MA: Results of primary total knee arthroplasty in Jehovah's Witness patients. J Arthroplasty 2013; 28:49-55
2. Whitson BA, HuddLeston SJ, Savik K,Shumway SJ: Bloodless cardiac surgery is associated with decreased morbidity and mortality. J Card Surg 2007; 22:373-378

Observational studies, case reports, or non-pertinent comparison groups

1. Harwin SF, Pivec R, Johnson AJ, Naziri Q, Mont MA: Revision total hip arthroplasty in Jehovah's Witnesses. Orthopedics 2012; 35:e1145-e1151
2. Jassar AS, Ford PA, Haber HL, Isidro A, Swain JD, Bavaria JE, Bridges CR: Cardiac surgery in Jehovah's Witness patients: ten-year experience. Ann Thorac Surg 2012; 93:19-25
3. Jo KI, Shin JW, Choi TY, Park YJ, Youm W, Kim MJ: Eight-year experience of bloodless surgery at a tertiary care hospital in Korea. Transfusion 2013; 53:948-954
4. Magner D, Ouellette JR, Lee JR, Colquhoun S, Lo S, Nissen NN: Pancreaticoduodenectomy after neoadjuvant therapy in a Jehovah's witness with locally advanced pancreatic cancer: case report and approach to avoid transfusion. Am Surg 2006; 72:435-437
5. Moraca RJ, Wanamaker KM, Bailey SH, McGregor WE, Benckart DH, Maher TD, Magovern GJ Jr: Strategies and outcomes of cardiac surgery in Jehovah's Witnesses. J Card Surg 2011; 26:135-143
6. Pasic M, D'Ancona G, Unbehaun A, Hetzer R: Bloodless third complex heart operation in a Jehovah's Witness patient with extremely low preoperative haemoglobin level. Interact Cardiovasc Thorac Surg 2012; 14:692-693
7. Podesta A, Parodi E, Dottori V, Crivellari R, Passerone GC: Epoetin alpha in elective coronary and valve surgery in Jehovah's Witnesses patients. Experience in 45 patients. Minerva Cardioangio 2002; 50:125-131
8. Stoye A, Chapin JW, Botha J, Grant W: Bloodless liver transplantation in a Jehovah's Witness. Int Anesthesiol Clin 2011; 49:108-115
9. Vaislic CD, Dalibon N, Ponzio O, Ba M, Jugan E, Lagneau F, Abbas P, Olliver Y, Gaillard D, Baget F, Sportiche M, Chedid A, Chaoul G, Maribas P, Dupuy C, Robine B, Kasanin N, Michon H, Ruat JM, Habis M, Bouharaoua T: Outcomes in cardiac surgery in 500 consecutive Jehovah's Witness patients: 21 year experience. J Cardiothorac Surg 2012; 7:95

Massive transfusion protocol:

Nonrandomized comparative studies:

1. Simmons JW, White CE, Eastridge BJ, Mace JE, Wade CE, Blackbourne LH: Impact of policy change on US Army combat transfusion practices. J Trauma 2010; 69 (Suppl 1):S75-S80

Observational studies, case reports, or non-pertinent comparison groups:

1. Gutierrez MC, Goodnough LT, Druzin M, Butwick AJ: Postpartum hemorrhage treated with a massive transfusion protocol at a tertiary obstetric center: a retrospective study. Int J Obstet Anesth 2012; 21:230-235

Maximum surgical blood ordering schedule for elective procedures:

Randomized controlled trials:

1. Nuttall GA, Santrach PJ, Oliver WC Jr, Ereth MH, Horlocker TT, Cabanela ME, Trousdale RT, Bryant S, Currie TW: A prospective randomized trial of the surgical blood order equation for ordering red blood cells for total hip arhtroplasy patients. Transfusion 1998; 38:828-833

Observational studies, case reports, or non-pertinent comparison groups:

1. Dexter F, Ledolter J, Davis E, Witkowski TA, Herman JH, Epstein RH: Systematic criteria for type and screen based on procedure's probability of erythrocyte transfusion. Anesthesiology 2012 116:768-778
2. Frank SM, Rothschild JA, Masear CG, Rivers RJ, Merritt WT, Savage WJ, Ness PM: Optimizing preoperative blood ordering with data acquired from an anesthesia information management system. Anesthesiology 2013; 118:1286-1297
3. Kajja I, Bimenya GS, Eindhoven GB, ten Duis HJ, Sibinga CT: Surgical blood order equation in femoral fracture surgery. Transfus Med 2011; 21:7-12
4. Karger R, Bornmann A, Kretschmer V: Limited utility of algorithms predicting blood transfusions. Blood Transfus 2013; 11:426-432
5. Krupp NL, Weinstein G, Chalian A, Berlin Jam Wolf P, Weber RS: Validation of a transfusion prediction model in head and neck cancer surgery. Arch Otolaryngol Head Neck Surg 2003; 129:1297-1302
6. Mahadevan D, Challand C, Clarke A, Keenan J: Maximum surgical blood ordering schedules for revision lower limb arthroplasty. Arch Orthop Trauma Surg 2011; 131:663-667
7. Nuttall GA, Horlocker TT, Santrach PJ, Oliver WC Jr, Dekutoski MB, Bryant S: Use of the surgical blood order equation in spinal instrumentation and fusion surgery. Spine 2000; 25:602-605
8. Palmer T, Wahr JA, O'Reilly M, Greenfield ML: Reducing unnecessary cross-matching: a patient-specific blood ordering system is more accurate in predicting who will receive a blood transfusion than the maximum blood ordering system. Anesth Analg 2003; 96:369-375
9. Subramanian A, Sagar S, Kumar S, Agrawal D, Albert V, Misra MC: Maximum surgical blood ording schedule in a tertiary trauma center in northern India. J Emerg Trauma Schock 2012; 5:312-327
10. Van Klei WA, Moons KG, Leyssius AT, Knape JT, Rutten CL, Grobee DE: A reduction in type and screen: Preoperative prediction of RBC transfusions in surgery procedures with intermediate transfusion risks. Br J Anaesth 2001; 87:250-257

Allogeneic red blood cell transfusion.

Age of stored RBCs:

Nonrandomized comparative studies:

1. Andreasen JJ, Dethlefsen C, Modrau IS, Baech J, Schonheyder HC, Moeller JK, Johnsen SP: Storage time of allogeneic red blood cells is associated with risk of severe postoperative infection after coronary artery bypass grafting. Eur J Cardiothorac Surg 2011; 39:329-334

2. Cata JP, Klein EA, Hoeltge GA, Dalton JE, Mascha E, O'Hara J, Russell A, Kurz A, Ben-Elihayhu S, Sessler DI: Blood storage duration and biochemical recurrence of cancer after radical prostatectomy. Mayo Clin Proc 2011; 86:120-127
3. Chen J, Singhapricha T, Memarzadeh M, Ziman A, Yuan S, Hu KQ, Steadman RH, Busuttil RW, Xia VW: Storage age of transfused red blood cells during liver transplantation and its intraoperative and postoperative effects. World J Surg 2012; 36:2436-2442
4. Edgren G, Kamper-Jørgensen M, Eloranta S, Rostgaard K, Custer B, Ullum H, Murphy EL, Busch MP, Reilly M, Melbye M, Hjalgrim H, Nyrén O: Duration of red blood cell storage and survival of transfused patients (CME). Transfusion 2010; 50:1185-1195
5. Koch CG, Li L, Sessler DI, Figueroa P, Hoeltge GA, Mihaljevic T, Blackstone EH: Duration of red-cell storage and complications after cardiac surgery. N Engl J Med 2008; 358:1229-1239
6. McKenny M, Ryan T, Tate H, Graham B, Young VK, Dowd N: Age of transfused blood is not associated with increased postoperative adverse outcome after cardiac surgery. Br J Anaesth 2011; 106:643-649
7. Mynster T, Nielsen HJ: The impact of storage time of transfused blood on postoperative infectious complications in rectal cancer surgery. Scand J Gastroenterol 2000; 35:212-217
8. Vamvakas EC, Carven JH: Length of storage of transfused red cells and postoperative morbidity in patents undergoing coronary artery bypass graft surgery. Transfusion 2000; 40:101-109
9. van de Watering L, Lorinser J, Versteegh M, Westendord R, Brand A: Effects of storage time of red blood cell transfusions on the prognosis of coronary artery bypass graft patients. Transfusion 2006; 46:1712-1718
10. van Straten AH, Soliman Hamad MA, van Zundert AA, Mertens EJ, ter Woorst JF, de Wolf AM, Scharnhorst V: Effect of duration of red cell storage on early and late mortality after coronary artery bypass grafting. J Thorac Cardiovasc Surg 2011; 141:231-237

Observational studies, case reports, or non-pertinent comparison groups

1. Hebert PC, Chin-Yee I, Fergusson D, Blajchman M, Martineau R, Clinch J, Olberg B: A pilot trial evaluating the clinical effects of prolonged storage of red cells. Anesth Analg 2005; 100:1433-1438
2. Saager L, Turan A, Dalton JE, Figueroa PI, Sessler DI, Kurz A: Erythrocyte storage duration is not associated with increased mortality in noncardiac surgical patients: A retropective analysis of 6,994 patients. Anesthesiology 2013; 118:51-58
3. Vamvakas EC, Carven JH: Transfusion and postoperative pneumonia in coronary artery bypass graft surgery: effect of the length of storage of transfused red cells. Transfusion 1999; 39:701-710
4. Yap CH, Lau L, Krishnaswamy M, Gaskell M, Yii M: Age of transfused red cells and early outcomes after cardiac surgery. Ann Thorac Surg 2008; 86:554-559

Leukocyte reduction:

Randomized controlled trials:

1. Bilgin YM, van de Watering LM, Eijsman L, Versteegh MI, Brand R, van Oers MH, Brand A: Double-blind, randomized controlled trial on the effect of leukoreduced erythrocyts transfusions in cardiac valve surgery. Circulation 2004; 109:2755-2760

2. Houbiers JG, Brand A, van de Watering LM, Hermans J, Verwey PJ, Bijnen AB, Pahlplatz P, Eeftinck Schattenkerk M, Wobbes T, de Vries JE: Randomised controlled trial comparing transfusion of leukocyte-depleted or buffy-coat-depleted blood in colorectal cancer. Lancet 1994; 344:573-578
3. Jensen LS, Andersen AJ, Christiansen PM, Hokland P, Juhl CO, Madsen G, Mortensen J, Moller-Nielsen C, Hanberg-Sorensen F, Hokland M: Postoperative infection and natural killer cell function following blood transfusion in patients undergoing elective colorectal surgery. Br J Surg 1992; 79:513-516
4. Jensen LS, Kissmeyer-Nielsen P, Wolff B, Qvist N: Randomised comparison of leucocyte-depleted versus buffy-coat-poor blood transfusion and complications after colorectal surgery. Lancet 1996; 348:841-845
5. Tartter PI, Mohandas K, Azar P, Endres J, Kaplan J, Spivack M: Randomized trial comparing packed red blood cell transfusion with and without leukocyte depletion for gastrointestinal surgery. Am J Surg 1998; 176:462-466
6. Titlestad IL, Ebbesen LS, Ainsworth AP, Lillevang ST, Qvist N, Georgsen J: Leukocyte-depletion of blood components does not significantly reduce the risk of infectious complications. Int J Colorectal Dis 2001; 16:147-153
7. van de Watering LM, Hermans J, Houbiers JG, van den Broek PJ, Bouter H, Boer H, Harvey MS, Huysmans HA, Brand A: Beneficial effects of leukocyte depletion of transfused blood on postoperative complications in patients undergoing cardiac surgery: a randomized clinical trial. Circulation 1998; 97:562-568

Observational studies, case reports, or non-pertinent comparison groups

1. Blumberg N, Heal JM, Gettings KF, Phipps RP, Masel D, Refaai MA, Kirkley SA, Fialkow LB: An association between decreased cardiopulmonary complications (TRALI and TACO) and implementation of universal leukoreduction of blood transfusions. Transfusion 2010; 50:2738-2744
2. Wallis JP, Chapman CE, Orr KE, Clark SC, Forty JR: Effect of WBC reduction of transfused RBCs on postoperative infection rates in cardiac surgery. Transfusion 2002; 42:1127-1134

Autologous red blood cell transfusion.

Intraoperative blood recovery:

Randomized controlled trials:

1. Clagett GP, Valentine RJ, Jackson MR, Mathison C, Kakish HB, Bengtson TD: A randomized trial of intraoperative autotransfusion during aortic surgery. J Vasc Surg 1999; 29:22-30
2. Daane CR, Golab HD, Meeder JH, Wijers MJ, Bogers AJ: Processing and transfusion of residual cardiopulmonary bypass volume: effects on harmostasis, complement activation, postoperative blood loss and transfusion volume. Perfusion 2003; 18:115-121
3. Damgaard S, Steinbruchel DA: Autotransfusion with cell saver for off-pump coronary artery bypass surgery: a randomized trial. Scand Cardiovasc J 2006; 40:194-198
4. Ekback G, Schott U, Axelsson K, Carlberg M: Perioperative autotransfusion and functional coagulation analysis in total hip replacement. Acta Anaesthes Scand 1995; 39:390-395
5. Goel P, Pannu H, Mohan D, Arora R: Efficacy of cell saver in reducing homologous blood transfusions during OPCAB surgery: a prospective randomized trial. Transfus Med 2007; 17:285-289

6. Laub GW, Dharan M, Riebman JB, Chen C, Moore R, Bailey BM, Fernandez J, Adkins MS, Anderson W, McGrath LB: The impact of intraoperative autotransfusion on cardiac surgery. A prospective randomized double-blind study. Chest 1993; 104:686-689
7. Marcheix B, Carrier M, Martel C, Cossette M, Pellerin M, Bouchard D, Perrault LP: Effect of pericardial blood processing on postoperative inflammation and the complement pathways. Ann Thorac Surg 2008; 85:530-535
8. McGill N, O'Shaughnessy D, Pickering R, Herbertson M, Gill R: Mechanical methods of reducing blood transfusion in cardiac surgery: randomised controlled trial. BMJ 2002; 324:1299-303
9. Mercer KG, Spark JI, Berridge DC, Kent PJ, Scott DJ: Randomized clinical trial of intraoperative autotransfusion in surgery for abdominal aortic aneurysm. Br J Surg 2004; 91:1443-1448
10. Murphy GJ, Rogers CS, Lansdowne WB, Channon I, Alwair H, Cohen A, Caputo M, Angelini GD: Safety, efficacy, and cost of intraoperative cell salvage and autotransfusion after off-pump coronary artery bypass surgery: a randomized trial. J Thorac Cardiovasc Surg 2005; 130:20-28
11. Niranjan G, Asimakopoulos G, Karagounis A, Cockerill G, Thompson M, Chandrasekaran V: Effects of cell saver autologous blood transfusion on blood loss and homologous blood transfusion requirements in patients undergoing cardiac surgery on- versus offcardiopulmonary bypass: a randomised trial. Eur J Cardiothorac Surg 2006; 30:271-277
12. Prieto MA, Guash S, Mendez JC, Munoz C, Planas A, Reyes G: Does use of cell saver decrease the inflammatory response in cardiac surgery? Asian Cardiovasc Thorac Ann 2013; 21:37-42
13. Rainaldi MP, Tazzari PL, Scagliarini G, Borghi B, Conte R: Blood salvage during caesarean section. Br J Anaesth 1998; 80:195-198
14. Rollo VJ, Hozack WJ, Rothman RH, Chao W, Eng KO: Prospective randomized evaluation of blood salvage techniques for primary total hip arthroplasty. J Arthroplasty 1995; 10:532-539
15. Spark JI, Chetter IC, Kester RC, Scott DJ: Allogeneic versus autologous blood during abdominal aortic aneurysm surgery. Eur J Vasc Endovasc Surg 1997; 14:482-486

Nonrandomized comparative studies

1. Benli IT, Akalin S, Duman E, Citak M, Kis M: The results of intraoperative autotransfusion in orthopaedic surgery. Bull Hosp Jt Dis 1999; 58:184-187
2. Bridgens JP, Evans CR, Dobson PM, Hamer AJ: Intraoperative red blood-cell salvage in revision hip surgery. A case-matched study. J Bone Joint Surg Am 2007; 89:270-275
3. Connor JP, Morris PC, Alagoz T, Anderson B, Bottles K, Buller RE: Intraoperative autologous blood collection and autotransfusion in the surgical management of early cancers of the uterine cervix. Obstet Gynecol 1995; 86:373-378
4. del Trujillo MM, Carrero A, Muñoz M: The utility of the perioperative autologous transfusion system OrthoPAT in total hip replacement surgery: a prospective study. Arch Orthop Trauma Surg 2008; 128:1031-1038
5. Gilbert JB, Malkowicz SB, Wein AJ: Cell saver and radical retropubic prostatectomy: analysis of cost-effectiveness. Urology 1995; 46:542-544
6. Kilgore ML, Pacifico AD: Shed mediastinal blood transfusion after cardiac operations: a cost-effectiveness analysis. Ann Thorac Surg 1998; 65:1248-1254

7. Posacioglu H, Apaydin AZ, Islamoglu F, Calkavur T, Yagdi T, Atay Y, Buket S: Adverse effects of cell saver in patients undergoing ruptured abdominal aortic aneurysm repair. Ann Vasc Surg 2002; 16:450-455
8. Rebarber A, Lonser R, Jackson S, Copel JA, Sipes S: The safety of intraoperative autologous blood collection and autotransfusion during cesarean section. Am J Obstet Gynecol 1998; 179:715-720
9. Roberts WA, Kirkley SA, Newby M: A cost comparison of allogeneic and preoperatively or intraoperatively donated autologous blood. Anesth Analg 1996; 83:129-133
10. Schmied H, Schiferer A, Sessler DI, Meznik C: The effects of red-cell scavenging, hemodilution, and active warming on allogenic blood requirements in patients undergoing hip or knee arthroplasty. Anesth Analg 1998; 86:387-391
11. Serrano FJ, Monux G, Aroca M: Should the cell saver autotransfusion system be routinely used in elective aortic surgery? Ann Vasc Surg 2000; 14:663-668
12. Wang MJ, Chen TL, Huang CH, Chao A, Chu SH: Difference in efficacy of the Cell Saver in coronary bypass grafting surgery and cardiac valvular reoperations. J Formos Med Assoc 1994; 93:117-121
13. Yamada T, Yamashita Y, Terai Y, Ueki M: Intraoperative blood salvage in abdominal uterine myomectomy. Int J Gynaecol Obstet 1997; 56:141-145

Observational studies, case reports, or non-pertinent comparison groups

1. Bartels C, Claeys L, Ktenidis K, Nigbur H, Horsch S: Intraoperative whole blood autotransfusion during venous thrombectomy. J Cardiovasc Surg 1994; 35:109-114
2. Burman JF, Westlake AS, Davidson SJ, Rutherford LC, Rayner AS, Wright AM, Morgan CJ, Pepper JR: Study of five cell salvage machines in coronary artery surgery. Transfus Med 2002; 12:173-179
3. Chanda A, Smith DR, Nanda A: Autotransfusion by cell saver technique in surgery of lumbar and thoracic spinal fusion with instrumentation. J Neurosurg 2002; 96:298-303
4. Djaiani G, Fedorko L, Borger MA, Green R, Carroll J, Marcon M, Karski J: Continuous-flow cell saver reduces cognitive decline in elderly patients after coronary bypass surgery. Circulation 2007; 116:1888-1895
5. Gardner A, Gibbs N, Evans C, Bell R: Relative cost of autologous red cell salvage versus allogeneic red cell transfusion during abdominal aortic aneurysm repair. Anaesth Intensive Care 2000; 28:646-649
6. Glazier DB, Ciocca RG, Gosin JS, Murphy DP, Graham AM: Elective aortic surgery with minimal banked blood. Am Surg 1998; 64:171-174
7. Goodnough LT, Monk TG, Sicard G, Satterfield SA, Allen B, Anderson CB, Thompson RW, Flye W, Martin K: Intraoperative salvage in patients undergoing elective abdominal aortic aneurysm repair: an analysis of cost and benefit. J Vasc Surg 1996; 24:213-218
8. Huber TS, Carlton LC, Irwin PB, Flug RR, Harward TR, Flynn TC, Seeger JM: Intraoperative autologous transfusion during elective infrarenal aortic reconstruction. J Surg Res 1997; 67:14-20
9. Kemper RR, Menitove JE, Hanto DW: Cost analysis of intraoperative blood salvage during orthotopic liver transplantation. Liver Transpl Surg 1997; 3:513-517
10. Klodell CT, Richardson JD, Bergamini TM, Spain DA: Does cell-saver blood administration and free hemoglobin load cause renal dysfunction? Am Surg 2001; 67:44-47
11. Marty-Ane CH, Alric P, Picot MC, Picard E, Colson P, Mary H: Ruptured abdominal aortic aneurysm: influence of intraoperative management on surgical outcome. J Vasc Surg 1995; 22:780-786

12. Murphy GJ, Allen SM, Unsworth-White J, Lewis CT, Dalrymple-Hay MJ: Safety and efficacy of perioperative cell salvage and autotransfusion after coronary artery bypass grafting: a randomized trial. Ann Thorac Surg 2004; 77:1553-1559
13. Ott DA, Cooley DA: Cardiovascular surgery in Jehovah's Witnesses. Report of 542 operations without blood transfusion. JAMA 1977; 232:1256-1258
14. Ralph CJ, Sullivan I, Faulds J: Intraoperative cell salvaged blood as part of a blood conservation strategy in Cesarean section: is fetal red cell contamination important? Br J Anaesth 2011; 107:404-408
15. Rubens FD, Boodhwani M, Mesana T, Wozny D, Wells G, Nathan HJ: The cardiotomy trial: a randomized, double-blind study to assess the effect of processing of shed blood during cardiopulmonary bypass on transfusion and neurocognitive function. Circulation 2007; 116: I-89-I-97.
16. Simonian PT, Robinson RP: Titanium contamination of recycled Cell Saver blood in revision hip arthroplasty. J Arthroplasty 1995; 10:83-86
17. Szalay D, Wong D, Lindsay T: Impact of red cell salvage on transfusion requirements during elective abdominal aortic aneurysm repair. Ann Vasc Surg 1999; 13:576-581
18. Tawes RL Jr, Duvall TB: Is the "salvaged-cell syndrome" myth or reality? Am J Surg 1996; 172:172-174
19. Waters JH, Biscotti C, Potter PS, Phillipson E: Amniotic fluid removal during cell salvage in the cesarean section patient. Anesthesiology 2000; 92:1531-1536
20. Waters JH, Lukauskiene E, Anderson ME: Intraoperative blood salvage during cesarean delivery in a patient with β thalassemia intermedia. Anesth Analg 2003; 97:1808-1809
21. Waters JH, Sprung J: Errors during intraoperative cell salvage because of inappropriate wash solutions. Anesth Analg 2001; 93:1483-1485

Postoperative blood recovery:

Randomized controlled trials; cell salvage:

1. Axford TC, Dearani JA, Ragno G, MacGregor H, Patel MA, Valeri CR, Khuri SF: Safety and therapeutic effectiveness of reinfused shed blood after open heart surgery. Ann Thorac Surg 1994; 57:615-622
2. Dalrymple-Hay MJ, Dawkins S, Pack L, Deakin CD, Sheppard S, Ohri SK, Haw MP, Livesey SA, Monro JL: Autotransfusion decreases blood usage following cardiac surgery - a prospective randomized trial. Cardiovasc Surg 2002; 9:184-187
3. Moonen AF, Knoors NT, van Os JJ, Verburg AD, Pilot P: Retransfusion of filtered shed blood in primary total hip and knee arthroplasty: a prospective randomized clinical trial. Transfusion 2007; 47:379-384
4. Riou B, Arock M, Guerrero M, Ramos M, Thoreux P, Guillosson JJ, Roy-Camille R, Viars P: Haematological effects of postoperative autotransfusion in spinal surgery. Acta Anaesthesiol Scand 1994; 38:336-341
5. Sarkanović mL, Gvozdenović L, Savić D, Ilić MP, Jovanović G: Autologous blood transfusion in total knee replacement surgery. Vojnosanit Pregl 2013; 70:274-278
6. Shenolikar A, Wareham K, Newington D, Thomas D, Hughes J, Downes M: Cell salvage auto transfusion in total knee replacement surgery. Transfus Med 1997; 7:277-280
7. Thomas D, Wareham K, Cohen D, Hutchings H: Autologous blood transfusion in total knee replacement surgery. Br J Anaesth 2001; 86:669-673

Randomized controlled trials; whole blood:

1. Avall A, Hyllner M, Bengtson JP, Carlsson L, Bengtsson A: Greater increase in cytokine concentration after salvage with filtered whole blood than with washed red cells, but no difference in postoperative hemoglobin recovery. Transfusion 1999; 39:271-276
2. Bartels C, Bechtel JV, Winkler C, Horsch S: Intraoperative autotransfusion in aortic surgery: comparison of whole blood autotransfusion versus cell separation. J Vasc Surg 1996; 24:102-108
3. Daane CR, Golab HD, Meeder JH, Wijers MJ, Bogers AJ: Processing and transfusion of residual cardiopulmonary bypass volume: effects on harmostasis, complement activation, postoperative blood loss and transfusion volume. Perfusion 2003; 18:115-121
4. Jewell AE, Akowuah EF, Suvarna SK, Braidley P, Hopkinson D, Cooper G: A prospective randomised comparison of cardiotomy suction and cell saver for recycling shed blood during cardiac surgery. Eur J Cardiothorac Surg 2003; 23:633-636
5. Rollo VJ, Hozack WJ, Rothman RH, Chao W, Eng KO: Prospective randomized evaluation of blood salvage techniques for primary total hip arthroplasty. J Arthroplasty 1995; 10:532-539
6. Trubel W, Gunen E, Wuppinger G, Tschernko E, Gunen-Frank A, Staudacher M, Polterauer P: Recovery of intraoperatively shed blood in aortoiliac surgery: comparison of cell washing with simple filtration. Thorac Cardiovasc Surg 1995; 43:165-170

Nonrandomized comparative studies; cell salvage:

1. Ayers DC, Murray DG, Duerr DM: Blood salvage after total hip arthroplasty. J Bone Joint Surg Am 1995; 77:1347-1351
2. Body SC, Birmingham J, Parks R, Ley C, Maddi R, Shernan SK, Siegel LC, Stover EP, D'Ambra MN, Levin J, Mangano DT, Spiess BD: Safety and efficacy of shed mediastinal blood transfusion after cardiac surgery: a multicenter observational study. Multicenter Study of Perioperative Ischemia Research Group. J Cardiothorac Vasc Anesth 1999; 13:410-416
3. Grosvenor D, Goyal V, Goodman S: Efficacy of postoperative blood salvage following total hip arthroplasty in patients with and without deposited autologous units. J Bone Joint Surg Am 2000; 82-A:951-954
4. Sebastian C, Romero R, Olalla E, Ferrer C, Garcia-Vallejo JJ, Munoz M: Postoperative blood salvage and reinfusion in spinal surgery: blood quality, effectiveness and impact on patient blood parameters. Eur Spine J 2000; 9:458-465
5. Strumper D, Weber EW, Gielen-Wijffels S, Van Drumpt R, Bulstra S, Slappendel R, Durieux ME, Marcus MAE: Clinical efficacy of postoperative autologous transfusion of filtered shed blood in hip and knee arthroplasty. Transfusion 2004; 44:1567-1571

Nonrandomized comparative studies; whole blood:

1. Johnson HD, Morgan MS, Utley JR, Leyand SA, Nguyen-Duy T, Crawley DM: Comparative analysis of recovery of cardiopulmonary bypass residual blood: cell saver vs hemoconcentrator. J Extra Corpor Technol 1994; 26:194-199
2. Reents W, Babin-Ebell J, Misoph MR, Schwarzkopf A, Elert O: Influence of different autotransfusion devices on the quality of salvaged blood. Ann Thorac Surg 1999; 68:58-62

Observational studies, case reports, or non-pertinent comparison groups; cell salvage

1. Dich-Nielsen JO, Rajan RM, Jensen JJ: An anaphylactoid-like reaction following infusion of salvaged unwashed drain blood. Can J Anaesth 1998; 45:189
2. Healy Wl, Pfeifer BA, Kurtz SR, Johnson C, Johnson W, Johnston R, Sanders D, Karpman R, Hallack GN, Valeri CR: Evaluation of autologous shed blood for autotransfusion after orthopaedic surgery. Clin Orthop 1994; 299:53-59

Observational studies, case reports, or non-pertinent comparison groups; whole blood:

1. Jones HW, Savage L, White C, Goddard R, Lumley H, Kashif F, Gurusany K: Postoperative autologous blood salvage drains - are they useful in primary uncemented hip and knee arthroplasty? A prospective study of 186 cases. Acta Orthrop Belg 2004; 70:466-473

Intraoperative and postoperative patient monitoring.

Monitoring for inadequate perfusion and oxygenation of vital organs:

Randomized controlled trials:

1. Casati A, Fanelli G, Pietropaoli P: Continuous monitoring of cerebral oxygen saturation in elderly patients undergoing general abdominal surgery minimizes brain exposure to potential hypoxia. Anesth Analg 2005; 101:740-747
2. Murkin JM, Adams SJ, Novick RJ, Quantz M, Bainbridge D, Iglesias I, Cleland A, Schaefer B, Irwin G, Fox S: Monitoring brain oxygen saturation during coronary bypass surgery: a randomized prospective study. Anesth Analg 2007; 104:51-58

Observational studies, case reports, or non-pertinent comparison groups:

1. Abdelmalak BB, Cata JP, Bonilla A, You J, Kopyeva T, Vogel JD, Campbell S, Sessler DI: Intraoperative tissue oxygenation and postoperative outcomes after major non-cardiac surgery: an observational study. Br J Anaesth 2013; 110:241-249
2. Badner NH, Nicolaou G, Clarke CF, Forbes TL: Use of spinal near-infrared spectroscopy for monitoring spinal cord perfusion during endovascular thoracic aortic repairs. J Cardiothorac Vasc Anesth 2011; 25:316-319
3. Boezeman RP, Kelder JC, Waanders FG, de Vries JP: Continuous surveillance of lower limb perfusion during aortic surgery with near-infrared spectroscopy: a pilot study. Vasc Endovascular Surg 2011; 45:407-411
4. Casati A, Fanelli G, Pietropaoli P: Monitoring cerebral oxygen saturation in elderly patients undergoing general abdominal surgery: a prospective cohort study. Eur J Anaesthesiol 2007; 24:59-65
5. Cheng HW, Chang HH, Chen YJ, Chang WK, Chan KH, Chen PT: Clinical value of application of cerebral oximetry in total replacement of the aortic arch and concomitant vessels. Acta Anaesthesiol Taiwan 2008; 46:178-183
6. Cohn SM, Pearl RG, Acosta SM, Nowlin MU, Hernandez A, Guta C, Michalek JE: A prospective randomized pilot study of near-infrared spectroscopy-directed restricted fluid therapy versus standard fluid therapy in patients undergoing elective colorectal surgery. Am Surg 2010; 76:1384-1392
7. Govinda R, Kasuya Y, Bala E, Mahboobi R, Devarajan J, Sessler DI, Akça O: Early postoperative subcutaneous tissue oxygen predicts surgical site infection. Anesth Analg 2010; 111:946-952
8. Ives CL, Harrison DK, Stansby GS: Prediction of surgical site infections after major

surgery using visible and near-infrared spectroscopy. Adv Exp Med Biol 2007; 599:37-44
9. Senanayake E, Komber M, Nassef A, Massey N, Cooper G: Effective cerebral protection using near-infrared spectroscopy monitoring with antegrade cerebral perfusion during aortic surgery. J Card Surg 2012; 27:211-216
10. Uchino H, Nakamura T, Kuroda S, Houkin K, Murata J, Saito H: Intraoperative dual monitoring during carotid endarterectomy using motor evoked potentials and near-infrared spectroscopy. World Neurosurg 2012; 78:651-657

Monitoring for non RBC transfusion coagulopathy:

Platelet function monitoring:

Observational studies, case reports, or non-pertinent comparison groups:

1. Nuttall GA, Oliver WC Jr, Beynen FM, Dull JJ, Murray MJ, Nichols WL: Intraoperative measurement of activated partial thromboplastin time and prothrombin time by a portable laser photometer in patients following cardiopulmonary bypass. Cardiothorac Vasc Anesth 1993; 7:402-409
2. Orlov D, McCluskey SA, Selby R, Yip P, Pendergrast J, Karkouti K: Platelet dysfunction as measured by a point-of-care monitor is an independent predictor of high blood loss in cardiac surgery. Anesth Analg 2014; 118:257-263
3. Williams GD, Bratton SL, Riley EC, Ramamoorthy C: Coagulation tests during cardiopulmonary bypass correlate with blood loss in children undergoing cardiac surgery. J Cardiothorac Vasc Anesth 1999; 13:398-404

Viscoelastic haemostatic assays (VHA):

Randomized controlled trials; Thromboelastrography (TEG):

1. Wang SC, Shieh JF, Chang KY, Chu YC, Liu CS, Loong CC, Chan KH, Mandell S, Tsou MY: Thromboelastography-guided transfusion decreases intraoperative blood transfusion during orthotopic liver transplantation: randomized clinical trial. Transplant Proc 2010; 42:2590-2593

Nonrandomized comparative studies; Rotational thromboelastometry (ROTEM):

1. Trzebicki J, Flakiewicz E, Kosieradzki M, Blaszczyk B, Kołacz M, Jureczko L, Pacholczyk M, Chmura A, Lagiewska B, Lisik W, Wasiak D, Kosson D, Kwiatkowski A, Lazowski T: The use of thromboelastometry in the assessment of hemostasis during orthotopic liver transplantation reduces the demand for blood products. Ann Transplant 2010; 15:19-24

Observational studies, case reports, or non-pertinent comparison groups:

2. Andreasen JB, Hvas AM, Christiansen K, Ravn HB: Can RoTEM® analysis be applied for haemostatic monitoring in paediatric congenital heart surgery? Cardiol Young 2011; 21:684-691
3. Davidson SJ, McGrowder D, Roughton M, Kelleher AA: Can ROTEM thromboelastometry predict postoperative bleeding after cardiac surgery? J Cardiothorac Vasc Anesth 2008; 22:655-661
4. Coakley M, Reddy K, Mackie I, Mallett S: Transfusion triggers in orthotopic liver transplantation: a comparison of the thromboelastometry analyzer, the

thromboelastogram, and conventional coagulation tests. J Cardiothorac Vasc Anesth 2006; 20:548-553
5. Gouvêa G, Diaz R, Auler L, Toledo R, Soluri A, Haack AG, de Oliveira MM, Vilanova B, Machado VR, Martinho JM: Perioperative coagulation profile in living liver donors as assessed by rotational thromboelastometry. Liver Transpl 2010; 16:387-392
6. Haas T, Spielmann N, Mauch J, Madjdpour C, Speer O, Schmugge M, Weiss M: Comparison of thromboelastometry (ROTEM®) with standard plasmatic coagulation testing in paediatric surgery. Br J Anaesth 2012; 108:36-41
7. Herbstreit F, Winter EM, Peters J, Hartmann M: Monitoring of haemostasis in liver transplantation: comparison of laboratory based and point of care tests. Anaesthesia 2010; 65:44-49
8. Lee GC, Kicza AM, Liu KY, Nyman CB, Kaufman RM, Body SC: Does rotational thromboelastometry (ROTEM) improve prediction of bleeding after cardiac surgery? Anesth Analg 2012; 115:499-506
9. Levrat A, Gros A, Rugeri L, Inaba K, Floccard B, Negrier C, David JS: Evaluation of rotation thrombelastography for the diagnosis of hyperfibrinolysis in trauma patients. Br J Anaesth 2008; 100: 792–797
10. Ogawa S, Szlam F, Chen EP, Nishimura T, Kim H, Roback JD, Levy JH, Tanaka KA: A comparative evaluation of rotation thromboelastometry and standard coagulation tests in hemodilution-induced coagulation changes after cardiac surgery. Transfusion. 2012; 52:14-22
11. Oswald E, Stalzer B, Heitz E, Weiss M, Schmugge M, Strasak A, Innerhofer P, Haas T: Thromboelastometry (ROTEM) in children: age-related reference ranges and correlations with standard coagulation tests. Br J Anaesth 2010; 105:827-835
12. Reinhöfer M, Brauer M, Franke U, Barz D, Marx G, Lösche W: The value of rotation thromboelastometry to monitor disturbed perioperative haemostasis and bleeding risk in patients with cardiopulmonary bypass. Blood Coagul Fibrinolysis 2008; 19:212-219
13. Stancheva A, Spassov L, Tzatchev K: Correlation between rotation thrombelastometry ROTEM analysis and standard haemostatic parameters during liver transplantation. Clin Lab 2011; 57:407-413
14. Tirosh-Wagner T, Strauss T, Rubinshtein M, Tamarin I, Mishaly D, Paret G, Kenet G: Point of care testing in children undergoing cardiopulmonary bypass. Pediatr Blood Cancer 2011; 56:794-798
15. Weber CF, Gorlinger K, Meininger D, Herrmann E, Bingold T, Moritz A, Cohn LH, Zacharowski K: Point-of-care testing: a prospective, randomized clinical trial of efficacy in coagulopathic cardiac surgery patients. Anesthesiology 2012; 117:531-547

Monitoring (periodic checking) for adverse effects of transfusions:

Transfusion-related acute lung injury (TRALI):

Observational studies, case reports, or non-pertinent comparison groups:

1. Bux J, Becker F, Seeger W, Kilpatrick D, Chapman J, Waters A: Transfusion-related acute lung injury due to HLA-A2-specific antibodies in recipient and NB1-specific antibodies in donor blood. Br J Haematol 1996; 93:707-713
2. Chung YT, Wu YC, Chen YH: Postoperative pulmonary edema, transfusion-related?--a case report. Acta Anaesthesiol Sin 2003; 41:43-46
3. Toy P, Gajic O, Bacchetti P, Looney MR, Gropper MA, Hubmayr R, Lowell CA, Norris PJ, Murphy EL, Weiskopf RB, Wilson G, Koenigsberg M, Lee D, Schuller R, Wu P,

Grimes B, Gandhi MJ, Winters JL, Mair D, Hirschler N, Rosen RS, Matthat MA: Transfusion-related acute lung injury: incidence and risk factors. Blood 2012; 119:1757-1767

Hemolytic transfusion reactions (ABO incompatibility):

Observational studies, case reports, or non-pertinent comparison groups:

1. Yasuda H, Ohto H, Yamaguchi O, Sakuma S, Suzuki T, Mita M, Tsuneyama H, Uchikawa M: Three episodes of delayed hemolytic transfusion reactions due to multiple red cell antibodies, anti-Di, anti-Jk and anti-E. Transfus Sci 2000; 23:107-112

Bacterial contamination:

Nonrandomized comparative studies:

1. Chelemer SB, Prato BS, Cox PM Jr, O'Connor GT, Morton JR: Association of bacterial infection and red blood cell transfusion after coronary artery bypass surgery. Ann Thorac Surg 2002; 73:138-142
2. Koch CG, Li L, Duncan AI, Mihaljevic T, Cosgrove DM, Loop FD, Starr NJ, Blackstone EH: Morbidity and mortality risk associated with red blood cell and blood-component transfusion in isolated coronary artery bypass grafting. Crit Care Med 2006; 34:1608-1616
3. Murphy GJ, Reeves BC, Rogers CA, Rizve SI, Culliford L, Angelini GD: Increased mortality, postoperative morbidity and cost after red blood cell transfusion in patients having cardiac surgery. Circulation 2007; 116:2544-2552
4. Sreeram GM, Welsby IJ, Sharma AD, Philips-Bute B, Smith PK, Slaughter TF: Infectious complications after cardiac surgery: lack of association with FFP of platelet transfusions. J Cardiothorac Vasc Anesth 2005; 19:430-434

Observational studies, case reports, or non-pertinent comparison groups

1. Banbury MK, Brizzio ME, Rajeswaran J, Lytle BW, Blackstone EH: Transfusion increases the risk of postoperative infection after cardiac surgery. J Am Coll Surg 2006; 202:131-138
2. Dzik WH, Andersen JK, O'Neill EM, Assmann SF, Kalish LA, Stowell CP: A prospective, randomized clinical trial of universal WBC reduction. Transfusion 2002; 42:1114-1122

Treatment of excessive bleeding.

Platelet transfusion (PLT or A-PLT):

Nonrandomized comparative studies:

1. Pereboom ITA, de Boer MT, Haagsma EB, Hendriks HGD, Lisman T, Porte RJ: Platelet transfusion during liver transplantation is associated with increased postoperative mortality due to acute lung injury. Anesth Analg 2009; 108:1083-1091

Observational studies, case reports, or non-pertinent comparison groups

1. Lemmer JH Jr, Metzdorff MT, Krause AH Jr, Martin MA, Okies JE, Hill JG: Emergency coronary artery bypass graft surgery in abciximab-treated patients. Ann Thorac Surg 2000; 69:90-95

Fresh frozen plasma transfusion (FFP or A-FFP):

Randomized controlled trials:

1. Consten ECJ, Henny CP, Eijsman L, Dongelmans DA, van Oers MHJ: The routine use of fresh frozen plasma in operations with cardiopulmonary bypass is not justified. J Thorac Cardiovasc Surg 1996; 112:162-167
2. Wilhelmi M, Franke U, Cohnert T, Weber P, Kaukemuller J, Fischer S, Wahlers T, Haverich A: Coronary artery bypass grafting surgery without the routine application of blood products: Is it feasible? Eur J Cardiothorac Surg 2001; 19:657-661

Observational studies, case reports, or non-pertinent comparison groups

1. Lindgren L, Yli-Hankala A, Halme L, Koskimies S, Orko R: Transfusion-related acute lung injury (TRALI) after fresh frozen plasma in a patient with coagulopathy. Acta Anaesthesiol Scand 1996; 40:641-644
2. Murray DJ, Pennell BJ, Weinstein SL, Olson JD: Packed red cells in acute blood loss: Dilutional coagulopathy as a cause of surgical bleeding. Anesth Analg 1995; 80:336-342

Pharmacologic treatments:

Desmopressin (DDAVP):

Randomized controlled trials; Desmopressin vs. placebo:

1. Alanay A, Acaroglu E, Ozdemir O, Ercelen O, Bulutcu E, Surat A: Effects of deamino-8-D-arginin vasopressin on blood loss and coagulation factors in scoliosis surgery. A double-blind randomized clinical trial. Spine 1999; 24:877-882
2. Casas JI, Zuazu-Jausoro I, Mateo J, Oliver A, Litvan H, Muniz-Diaz E, Aris A, Caralps JM, Fontcuberta J: Aprotinin versus desmopressin for patients undergoing operations with cardiopulmonary bypass. A double-blind placebo-controlled study. J Thorac Cardiovasc Surg 1995; 110:1107-1117
3. Despotis GJ, Levine V, Saleem R, Spitznagel E, Joist JH: Use of point-of-care test in identification of patients who can benefit from desmopressin during cardiac surgery: a randomised controlled trial. Lancet 1999; 354:106-110
4. Karnezis TA, Stulberg SD, Wixson RL, Reilly P: The hemostatic effects of desmopressin on patients who had total joint arthroplasty. A double-blind randomized trial. J Bone Joint Surg Am 1994; 76:1545-1550
5. Oliver WC Jr, Santrach PJ, Danielson GK, Nuttall GA, Schroeder DR, Ereth MH: Desmopressin does not reduce bleeding and transfusion requirements in congenital heart operations. Ann Thorac Surg 2000; 70:1923-1930
6. Pleym H, Stenseth R, Wahba A, Bjella L, Tromsdal A, Karevold A, Dale O: Prophylactic treatment with desmopressin does not reduce postoperative bleeding after coronary surgery in patients treated with aspirin before surgery. Anesth Analg 2004; 98:578-584
7. Sheridan DP, Card RT, Pinilla JC, Harding SM, Thomson DJ, Gauthier L, Drotar D: Use of desmopressin acetate to reduce blood transfusion requirements during cardiac surgery in patients with acetylsalicylic-acid-induced platelet dysfunction. Can J Surg 1994; 37:33-36
8. Temeck BK, Bachenheimer LC, Katz NM, Coughlin SS, Wallace RB: Desmopressin acetate in cardiac surgery: a double-blind, randomized study. South Med J 1994; 87:611-615

9. Wong AY, Irwin MG, Hui TW, Fung SK, Fan ST, Ma ES: Desmopressin does not decrease blood loss and transfusion requirements in patients undergoing hepatectomy. Can J Anaesth 2003; 50:14-20

Randomized controlled trials; Desmopressin vs. no Desmopressin:

1. Ozkisacik E, Islamoglu F, Posacioglu H, Yagdi T, Basarir S, Omay SB, Ozbaran M, Buket S: Desmopressin usage in elective cardiac surgery. J Cardiovasc Surg (Torino) 2001; 42:741-747
2. Rocha E, Hidalgo F, Llorens R, Melero JM, Arroyo JL, Paramo JA. Randomized study of aprotinin and DDAVP to reduce postoperative bleeding after cardiopulmonary bypass surgery. Circulation 1994; 90:921-927

Observational studies, case reports, or non-pertinent comparison groups

1. Beholz S, Liu J, Thoelke R, Spiess C, Konertz W: Use of desmopressin and erythropoietin in an anaemic Jehovah's Witness patient with severely impaired coagulation capacity undergoing stentless aortic valve replacement. Perfusion 2001; 16:485-489
2. Clagett GP, Valentine RJ, Myers SI, Chervu A, Heller J: Does desmopressin improve hemostasis and reduce blood loss from aortic surgery? A randomized, double-blind study. J Vasc Surg 1995; 22:223-229
3. Dave SP, Greenstein AJ, Sachar DB, Harpaz N, Aledort L: Bleeding diathesis in amyloidosis with renal insufficiency associated with Crohn's disease: response to desmopressin. Am J Gastroenterol 2002; 97:187-189
4. Franchini M, de Gironcoli M, Lippi G, Manzato F, Aprili G, Gandini G: Prophylactic use of desmopressin in surgery of six patients with symptomatic heterozygous factor XI deficiency. Haematologica 2000; 85:106-107

Antifibrinolytics (for treatment of excessive bleeding)

Randomized controlled trials; ε-Aminocaproic acid:

1. Ray MJ, Hales MM, Brown L, O'Brien MF, Stafford EG: Postoperatively administered aprotinin or epsilon aminocaproic acid after cardiopulmonary bypass has limited benefit. Ann Thorac Surg 2001; 72:521-526

Topical hemostatics; Fibrin glue:

Randomized controlled trials

1. Codispoti M, Mankad PS: Significant merits of a fibrin sealant in the presence of coagulopathy following paediatric cardiac surgery: randomised controlled trial. Eur J Cardiothorac Surg 2002; 22:200-205
2. Figueras J, Llado L, Miro M, Ramos E, Torras J, Fabregat J, Serrano T: Application of fibrin glue sealant after hepatectomy does not seem justified: results of a randomized study in 300 patients. Ann Surg 2007; 245:536-542
3. Jackson MR, Gillespie DL, Longenecker EG, Goff JM, Fiala LA, O'Donnell SD, Gomperts ED, Navalta LA, Hestlow T, Alving BM: Hemostatic efficacy of fibrin sealant (human) on expanded poly-tetrafluoroethylene carotid patch angioplasty: a randomized clinical trial. J Vasc Surg 1999; 30:461-466
4. Kjaergard HK, Trumbull HR: Vivostat system autologous fibrin sealant: preliminary study in elective coronary bypass grafting. Ann Thorac Surg 1998; 66:482-486

5. Kluba T, Fiedler K, Kunze B, Ipach I, Suckel A: Fibrin sealants in orthopaedic surgery practical experiences derived from use of QUIXIL® in total knee arthroplasty. Arch Orthop Trauma Surg 2012; 132:1147-1152
6. Levy O, Martinowitz U, Oran A, Tauber C, Horoszowski H: The use of fibrin tissue adhesive to reduce blood loss and the need for blood transfusion after total knee arthroplasty. A prospective, randomized, multicenter study. J Bone Joint Surg Am 1999; 81:1580-1588
7. Llewellyn-Bennett R, Greenwood R, Benson JR, English R, Turner J, Rayter Z, Winters ZE: Randomized clinical trial on the effect of fibrin sealant on latissimus dorsi donor-site seroma formation after breast reconstruction. Br J Surg 2012; 99:1381-1388
8. Mawatari M, Higo T, Tsutsumi Y, Shigematsu M, Hotokebuchi T: Effectiveness of autologous fibrin tissue adhesive in reducing postoperative blood loss during total hip arthroplasty: a prospective randomised study of 100 cases. J Orthop Surg (Hong Kong) 2006; 14:117-121
9. McConnell JS, Shewale S, Munro NA, Shah K, Deakin AH, Kinninmonth AW: Reduction of blood loss in primary hip arthroplasty with tranexamic acid or fibrin spray. Acta Orthop 2011; 82:660-663
10. Milic DJ, Perisic ZD, Zivic SS, Stanojkovic ZA, Stojkovic AM, Karanovic ND, Krstic NH, Salinger SS: Prevention of pocket related complications with fibrin sealant in patients undergoing pacemaker implantation who are receiving anticoagulant treatment. Europace 2005; 7:374-379
11. Notarnicola A, Moretti L, Martucci A, Spinarelli A, Tafuri S, Pesce V, Moretti B: Comparative efficacy of different doses of fibrin sealant to reduce bleeding after total knee arthroplasty. Blood Coagul Fibrinolysis 2012; 23:278-284
12. Rousou J, Levitsky S, Gonzalez-Lavin L, Cosgrove D, Magilligan D, Weldon C, Hiebert C, Hess P, Joyce L, Bergsland J, Gazzaniga A: Randomized clinical trial of fibrin sealant in patients undergoing resternotomy or reoperation after cardiac operations. A multicenter study. J Thorac Cardiovasc Surg 1989; 97:194-203
13. Sabatini L, Trecci A, Imarisio D, Uslenghi MD, Bianco G, Scagnelli R: Fibrin tissue adhesive reduces postoperative blood loss in total knee arthroplasty. J Orthop Traumatol 2012; 13:145-151
14. Saha SP, Muluk S, Schenk W 3rd, Dennis JW, Ploder B, Grigorian A, Presch I, Goppelt A: A prospective randomized study comparing fibrin sealant to manual compression for the treatment of anastomotic suture-hole bleeding in expanded polytetrafluoroethylene grafts. J Vasc Surg 2012; 56:134-141
15. Saha SP, Muluk S, Schenk W 3rd, Burks SG, Grigorian A, Ploder B, Presch I, Pavlova BG, Hantak E: Use of fibrin sealant as a hemostatic agent in expanded polytetrafluoroethylene graft placement surgery. Ann Vasc Surg 2011; 25:813-822
16. Segal N, Puterman M, Rotem E, Niv A, Kaplan D, Kraus M, Brenner H, Nash M, Tal A, Leiberman A: A prospective randomized double-blind trial of fibrin glue for reducing pain and bleeding after tonsillectomy. Int J Pediatr Otorhinolaryngol 2008; 72:469-473
17. Stoeckli SJ, Moe KS, Huber A, Schmid S: A prospective randomized double-blind trial of fibrin glue for pain and bleeding after tonsillectomy. Laryngoscope 1999; 109:652-655
18. Vaiman M, Eviatar E, Shlamkovich N, Segal S: Effect of modern fibrin glue on bleeding after tonsillectomy and adenoidectomy. Ann Otol Rhinol Laryngol 2003; 112:410-414
19. Wang GJ, Goldthwaite CA Jr, Burks S, Crawford R, Spotnitz WD: Fibrin sealant reduces perioperative blood loss in total hip replacement. J Long Term Eff Med Implants 2003; 13:399-411

20. Wang GJ, Hungerford DS, Savory CG, Rosenberg AG, Mont MA, Burks SG, Mayers SL, Spotnitz WD: Use of fibrin sealant to reduce bloody drainage and hemoglobin loss after total knee arthroplasty: a brief note on a randomized prospective trial. J Bone Joint Surg Am 2001; 83-A:1503-1505

Observational studies, case reports, or non-pertinent comparison groups

Yu L, Gu T, Song L, Shi E, Fang Q, Wang C, Zhao J: Fibrin sealant provides superior hemostasis for sternotomy compared with bone wax. Ann Thorac Surg 2012; 93:641-644

Topical hemostatics; Thrombin gel:

Randomized controlled trials

1. Chapman WC, Clavien PA, Fung J, Khanna A, Bonham A: Effective control of hepatic bleeding with a novel collagen-based composite combined with autologous plasma: results of a randomized controlled trial. Arch Surg 2000; 135:1200-1204
2. Mathiasen RA, Cruz RM: Prospective, randomized, controlled clinical trial of a novel matrix hemostatic sealant in children undergoing adenoidectomy. Otolaryngol Head Neck Surg 2004; 131:601-605
3. Powell DM, Chang E, Farrior EH: Recovery from deep-plane rhytidectomy following unilateral wound treatment with autologous platelet gel: a pilot study. Arch Facial Plast Surg 2001; 3:245-250

Prothrombin complex concentrates (PCC):

Observational studies, case reports, or non-pertinent comparison groups

1. Bhardwaj M, Bunsell R: Beriplex P/N: an alternative to fresh frozen plasma in severe haemorrhage. Anaesthesia 2007; 62:832-834
2. Bruce D, Nokes TJ: Prothrombin complex concentrate (Beriplex P/N) in severe bleeding: experience in a large tertiary hospital. Crit Care 2008; 12:R105
3. Lorenz R, Kienast J, Otto U, Kiehl M, Schreiter D, Haertel S, Barthels M: Successful emergency reversal of phenprocoumon anticoagulation with prothrombin complex concentrate: a prospective clinical study. Blood Coagul Fibrinolysis 2007; 18:565-570
4. Stuklis RG, O'Shaughnessy DF, Ohri SK: Novel approach to bleeding in patients undergoing cardiac surgery with liver dysfunction. Eur J Cardiothorac Surg 2001; 19:219-220

Coagulation factor concentrates; *Recombinant human activated Factor VII, Factor VIIa:*

Randomized controlled trials

1. Diprose P, Herbertson MJ, O'Shaughnessy D, Gill RS: Activated recombinant factor VII after cardiopulmonary bypass reduces allobeneic transfusion in complex non-coronary cardiac surgery: Randomized double-blind placebo-controlled pilot study. Br J Anaesth 2005; 95:596-602
2. Friederich PW, Henny CP, Messelink EJ, Geerdink MG, Keller T, Kurth KH, Buller HR, Levi M: Effect of recombinant activated factor VII on perioperative blood loss in patients undergoing retropubic prostatectomy: a double-blind placebo-controlled randomised trial. Lancet 2003; 361:201-205

3. Gill R, Herbertson M, Vuysteke A, Skov P, von Heymann C, Mythen M, Sellke F, Booth R, Schmidt TA: Safety and efficacy of recombinant activated factor VII. A randomized placebo-controlled trial in the setting of bleeding after cardiac surgery. Circulation 2009; 320:21-27
4. Johansson PI, Eriksen K, Nielsen SL, Rojkjaer R, Alsbjørn B: Recombinant FVIIa decreases perioperative blood transfusion requirement in burn patients undergoing excision and skin grafting--results of a single centre pilot study. Burns 2007; 33:435-440
5. Lodge JP, Jonas S, Jones RM, Olausson M, Mir-Pallardo J, Soefelt S, Garcia-Valdecasas JC, McAlister V, Mirza DF: Efficacy and safety of repeated perioperative doses of recombinant factor VIIa in liver transplantation. Liver Transpl 2005; 11:973-979
6. Lodge JP, Jonas S, Oussoultzoglou E, Malagó M, Jayr C, Cherqui D, Anthuber M, Mirza DF, Kuhlman L, Bechstein WO, Díaz JC, Tartiere J, Eyraud D, Fridberg M, Erhardtsen E, Mimoz O: Recombinant coagulation factor VIIa in major liver resection: a randomized, placebo-controlled, double-blind clinical trial. Anesthesiology 2005; 102:269-275
7. Planinsic RM, van der Meer J, Testa G, Grande L, Candela A, Porte RJ, Ghobrial M, Isoniemi H, Schelde PB, Erhardtsen E, Klintmalm G, Emre S: Safety and efficacy of a single bolus administration of recombinant factor VIIa in liver transplantation due to chronic liver disease. Liver Transpl 2005; 11:895-900
8. Raobaikady R, Redman J, Ball JA, Maloney G, Grounds RM: Use of activated recombinant coagulation factor VII in patients undergoing reconstruction surgery for traumatic fracture of pelvis or pelvis and acetabulum: a double-blind, randomized, placebo-controlled trial. Br J Anaesth 2005; 94:586-591
9. Shao YF, Yang JM, Chau GY, Sirivatanauksorn Y, Zhong SX, Erhardtsen E, Nivatvongs S, Lee PH: Safety and hemostatic effects of recombinant activated factor VII in cirrhotic patients undergoing partial hepatectomy; a multicenter, randomized, double-blind, placebo-controlled trial. Am J Surg 2006; 191:245-249

Nonrandomized comparative studies

1. Andersen ND, Bhattacharya SD, Williams JB, Fosbol EL, Lockhart EL, Patel MB, Gaca JG, Welsby IJ, Hughes GC: Intraoperative use of low-dose recombinant activated factor VII during thoracic aortic operations. Ann Thorac Surg 2012; 93:1921-1928
2. Gelsomino S, Lorusso R, Romagnoli S, Bevilacqua S, Dr Cicco G, Bille G, Stefano P, Gensini GF: Treatment of refractory bleeding after cardiac operations with low-dose recombinant activated factor VII (NovoSeven): A propensity score analysis. Eur J Cardiothorac Surg 2008; 33:64-71
3. Hendriks HG, Meijer K, de Wolf JT, Klompmaker IJ, Porte RJ, de Kam PJ, Hagenaars AJ, Melsen T, Slooff MJ, van der Meer J: Reduced transfusion requirements by recombinant factor VIIa in orthotopic liver transplantation: a pilot study. Transplantation 2001;71:402-405
4. Karkouti K, Beattie WS, Wijeysundera DN, Yau TM, McCluskey SA, Ghannam M, Sutton D, van Rensburg A, Karski J: Recombinant factor VIIa for intractable blood loss after cardiac surgery: A propensity score-matched case-control analysis. Transfusion 2005; 45:26-34
5. Tritapepe L, De Santix V, Vitale D, Nencini C, Pellegrini F, Landoni G, Toscano F, Miraldi F, Pirtropaoli P: Recombinant activated factor VII for refractory bleeding after acute aortic dissection surgery: A propensity score analysis. Crit Care Med 2007:1685-1690

6. von Heymann C, RedLich U, Jain U, Kastrup M, Schroeder T, Sander M, Grosse J, Ziemer S, Koscielny J, Fonertz WF, Wernecke KD, Spies C: Recombinant activated factor VII for refractory bleeding after cardiac surgery - A retrospective analysis of safety and efficacy. Crit Care Med 2005; 33:2241-2246

Observational studies, case reports, or non-pertinent comparison groups

1. Boyer-Neumann C, Dreyfus M, Wolf M, Veyradier A, Meyer D: Multi-therapeutic approach to manage delivery in an alloimmunized patient with type 3 von Willebrand disease. J Thromb Haemost 2003; 1:190-192
2. Bui JD, Despotic GD, Trulock EP, Patterson GA, Goodnough LT: Fatal thrombosis after administration of activated prothrombin complex concentrates in a patient supported by extracorporeal membrane oxygenation who had received activated recombinat factor VII. J Thorac Cardiovasc Surg 2002; 124:852-854
3. del Pozo Pozo AI, Jimenez-Yuste V, Villar A, Quintana M, Hernandez-Navarro F: Successful thyroidectomy in a patient with Hermansky-Pudlak syndrome treated with recombinant activated factor VII and platelet concentrates. Blood Coagul Fibrinolysis 2002; 13:551-553
4. Faber P, Reid C, El-Shafei H, Falase B, DeAnde A Jr, Mazer CD: Recombinant factor VIIa in the management of postoperative bleeding after repair for inadvertently thrombolysed acure type A aortic Dissection. J Cardiovasc Vasc Anesth 2006; 20:736-741
5. Lichtman AD, Carullo V, Minhaj M, Karkouti K: Case 6-2007: Massive intraoperative thrombosis and death after recombinant activated factor VII administration. J Cardiothorac Vasc Anesth 2007; 21:897-902
6. Moscardo F, Perez F, de la Rubia J, Balerdi B, Lorenzo JI, Senent ML, Aznar I, Carceller S, Sanz MA: Successful treatment of severe intra-abdominal bleeding associated with disseminated intravascular coagulation using recombinant activated factor VII. Br J Haematol 2001; 114:174-176
7. Pang G, Donaldson A: Probable right atrial thrombus immediately after recombinant activated factor VII administration. Br J Anaesth 2007; 99:221-225
8. Phillips LE, McLintock C, Pollock W, Gatt S, Popham P, Jankelowitz G, Ogle R, Cameron PA: Recombinant activated Factor VII in obstetric hamorrhage: experiences from the Australian and New Zealand haemostasis registry. Anesth Analg 2009; 109:1908-1915
9. Slappendel R, Huvers FC, Benraad B, Novakova I, van Hellenmondt GG: Use of recombinant factor VIIa to reduce postoperative bleeding after total hip arthroplasty in a patient with cirrhosis and thrombocytopenia. Anesthesiology 2002; 96:1525-1527
10. Stratmann G, Russell IA, Merrick SH: Use of recombinant factor VIIa as a rescue treatment for intractable bleeding following repeat aortic arch repair. Ann Thorac Surg 2003; 76:2094-2097
11. Sucker C, Sabel M, Stummer W, Zotz RB, Scharf RE, Gerhardt A: Recombinant factor VIIa for the prophylaxis of perioperative hemorrhage in a patient with congenital factor XI deficiency undergoing brain tumor neurosurgery. Clin Appl Thromb Hemost 2008; 14:472-475
12. Tobias JD: Synthetic factor VIIa to treat dilutional coagulopathy during posterior spinal fusion in two children. Anesthesiology 2002; 96:1522-1525
13. Sokolic V, Bukovic D, Fures R, Zadro M, Scuric I, Colak F, Celovec K, Bocan A: Recombinant factor VIIa (rFVIIa) is effective at massive bleeding after caesarean section--a case report. Coll Antropol 2002; 26 (Suppl):155-157
14. Svartholm E, Ammerhagen V, Lanne T: Treatment of bleeding in severe necrotizing pancreatitis with recombinant factor VIIa. Anesthesiology 2002; 96:1528

15. Van de Garde EMW, Bras LJ, Heijmen RH, Knibbe CAJ, Van Dongen EPA, Wiltink EHH, Biesma DH: Low-dose recombinant factor VIIa in the management of uncontrolled postoperative hemorrhage in cardiac surgery patients. J Cardiothorac Vasc Anesth 2006: 20:573-575
16. von Heymann C, Hotz H, Konertz W, Kox WJ, Spies C: Successful treatment of refractory bleeding with recombinant factor VIIa after redo coronary artery bypass graft surgery. J Cardiothorac Vasc Anesth 2002; 16:615-616
17. Warkentin TE, Margetts P, Connolly SJ, Lamy A, Ricci C, Eikelboom JW: Recombinant factor VIIa (rFVIIa) and hemodialysis to manage dabigatran-associated postcardiac surgey bleeding. Blood 2012; 119:2172-2174
18. White MC, Pyrn SJ, Monk CR: Thrombogenic side-effects of recombinant factor VIIa after use in coronary artery bypass surgery. Anaesth Intensive Care 2006; 34:664-667
19. Zupancic Salek S, Sokolic V, Viskovic T, Sanjug J, Simic M, Kastelan M: Successful use of recombinant factor VIIa for massive bleeding after caesarean section due to HELLP syndrome. Acta Haematol 2002; 108:162-163

Treatments for hypofibrinogenemia; Fibrinogen concentrate (Riastap™ or Haemocomplettan™):

Randomized controlled trials

1. Fenger-Eriksen C, Jensen TM, Kristensen BS, Jensen KM, Tønnesen E, Ingerslev J, Sørensen B: Fibrinogen substitution improves whole blood clot firmness after dilution with hydroxyethyl starch in bleeding patients undergoing radical cystectomy: a randomized, placebo-controlled clinical trial. J Thromb Haemost 2009; 7:795-802
2. Rahe-Meyer N, Solomon C, Hanke A, Schmidt DS, Knoerzer D, Hochleitner G, Sørensen B, Hagl C, Pichlmaier M: Effects of fibrinogen concentrate as first-line therapy during major aortic replacement surgery: a randomized, placebo-controlled trial. Anesthesiology 2013; 118:40-50

Observational studies, case reports, or non-pertinent comparison groups

1. Karlsson M, Ternström L, Hyllner M, Baghaei F, Flinck A, Skrtic S, Jeppsson A: Prophylactic fibrinogen infusion reduces bleeding after coronary artery bypass surgery. A prospective randomised pilot study. Thromb Haemost 2009; 102:137-144
2. Rahe-Meyer N, Solomon C, Winterhalter M, Pipenbrock S, Tanaka K, Haverich A, Pichlmaier M: Thrombolastometry-guided administration of fibrogen concentrate for the treatment of excessive intraoperative bleeding in thoracoabdominal aortic aneurysm surgery. J Thorac Cardiovasc Surg 2009; 138:694-702