References

1 *Asai T, Yamamoto K, Hirose T, Taguchi H, Shingu K.* Breakage of epidural catheters: a comparison of an Arrow reinforced catheter and other nonreinforced catheters. Anesth Analg 2001; 92: 246–8.

2 *Woehlck HJ, Bolla B.* Uncoiling of wire in Arrow Flextip epidural catheter on removal. Anesthesiology 2000; 92: 907–8.

3 *Staats PS, Stinson MS, Lee RR.* Lumbar stenosis complicating retained epidural catheter tip. Anesthesiology 1995; 83: 1115–8.

4 *Blanchard N, Clabeau JJ, Ossart M, Dekens J, Legars D, Tchaoussoff J.* Radicular pain due to a retained fragment of epidural catheter. Anesthesiology 1997; 87: 1567–9.

Use of acute normovolemic hemodilution for blood conservation during off-pump coronary artery bypass surgery

To the Editor:

Although the premise for using acute normovolemic hemodilution (ANH) as a blood conservation modality is sound,[1] results for patients undergoing cardiac surgery have been controversial.[2] Furthermore, use of ANH for off-pump coronary artery bypass (OPCAB) has never been described. Recently, I utilized ANH in a 67-yr-old male patient (90 kg) undergoing triple vessel OPCAB. Following anesthetic induction, ANH was performed to a hemoglobin (Hb) of 100 $g \cdot L^{-1}$ (collected four units [350 mL] of autologous whole blood [AWB]; replaced with an equal volume of 6% hetastarch in lactated electrolyte solution). My strategy was to transfuse AWB when Hb levels decreased below 90 $g \cdot L^{-1}$ during the OPCAB. One AWB unit was transfused after the internal mammary artery anastomosis (Table). During revascularization of the left circumflex artery (LCA) with a saphenous vein graft (SVG), occlusion of the artery produced ST segment elevation and hypotension (Table). Additional crystalloid, norepinephrine infusion and a 2.5-mm intracoronary shunt only partially reversed the ST segment changes. After documenting a Hb of 8.6 $g \cdot L^{-1}$, the second AWB unit was transfused, which was followed shortly thereafter by complete resolution of the ST segment changes. On completion of the last SVG to the right coronary artery, the remaining two AWB units were then transfused slowly (Table). Cell-saver blood (600 mL) was also reinfused producing a final Hb of 121 $g \cdot L^{-1}$ Postoperative recovery was uneventful and no allogeneic blood was transfused.

TABLE Chronology of intraoperative Hb levels during ANH and OPCAB surgery

Event	*Hb ($g \cdot L^{-1}$)*	*Response*
1st AWB unit complete	128	
2nd AWB unit complete	119	
3rd AWB unit complete	110	
4th AWB unit complete	101	
IMA anastomosis	89	1st AWB unit administered
L Cx anastomosis and myocardial ischemia	86	2nd AWB unit administered and resolution of myocardial ischemia
RCA anastomosis	95	
Post – protamine	94	3rd and 4th AWB units administered
Chest closure	114	auto CS administered
ICU admission	121	

Hb = hemoglobin; ANH = acute normovolemic hemodilution; OPCAB = off-pump coronary artery bypass; AWB = autologous whole blood; IMA = internal mammary artery; L Cx = left circumflex coronary artery; RCA = right coronary artery; auto CS = autologous cell-saver blood; ICU = intensive care unit.

Rosengart *et al.* advocate that for ANH to be effective, the "maximal" volume of AWB should be sequestered prior to cardiopulmonary bypass (CPB).[3] However, CPB also produces hemodilution, which limits the volume of AWB that may be sequestered prior to initiating CPB. In contrast, in patients undergoing OPCAB, since hemodilution associated with CPB is avoided, a "maximal" volume of AWB may be collected. The endpoint for blood sequestration and the intraoperative AWB transfusion threshold or "trigger" should be clearly defined; the actual timing of AWB reinfusion should also be carefully coordinated with the surgeon's efforts. In the above patient, since the transfusion of AWB promptly reversed ST-segment changes following LCA occlusion, inadequate Hb concentration was probably contributory to myocardial ischemia, suggesting that ANH should be used with caution for OPCAB. Since considerable variation in transfusion practices still exists among cardiac surgery centres,[3] ANH may represent a valuable blood conservation tool for OPCAB surgery. More information is clearly needed about its safety and efficacy for OPCAB.

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References

1 *Zauder HL, Stehling L.* Acute normovolemic hemodilution (Letter). J Clin Anesth 2000; 12: 498.

2 *Bryson GL, Laupacis A, Wells GA.* Does acute normov-

olemic hemodilution reduce perioperative allogeneic transfusion? A meta-analysis. The International Study of Perioperative Transfusion. Anesth Analg 1998; 86: 9–15.

3 *Stover EP, Siegel LC, Parks R, et al.* Variability in transfusion practice for coronary artery bypass surgery persists despite national consensus guidelines: a 24-institution study. Institutions of the Multicenter Study of Perioperative Ischemia Research Group. Anesthesiology 1998; 88: 327–33.

In vitro relationship between the blood nafamostat concentration and activated coagulation time

To the Editor:

The biological half-time of nafamostat (Torii Pharmaceutical, Tokyo, Japan), molecular weight 539.58, used as an anticoagulant in procedures such as continuous hemodiafiltration (CHDF) is approximately eight minutes.[1] Anticoagulation in the circuit is maintained adequately, whilst its concentration in the patient's blood decreases rapidly to a level which cannot cause anticoagulation, as measured by the activated coagulation time (ACT). We have routinely calculated the infusion dose of nafamostat using the patient's weight.[2] If the relationship between the blood nafamostat concentration and ACT is clarified, it may be possible to determine the dose of nafamostat alternatively.

After approval of our Institutional Committee, nafamostat was diluted with 5% glucose, and six plastic syringes were prepared, containing 0.1 mL of 5% glucose, 0.1 mL of 0.001 mg·mL^{-1} nafamostat, 0.1 mL of 0.01 mg·mL^{-1} nafamostat, 0.1 mL of 0.05 mg·mL^{-1} nafamostat, 0.1 mL of 0.1 mg·mL^{-1} nafamostat, and 0.1 mL of 0.5 mg·mL^{-1} nafamostat, respectively. 1.9 mL of blood from ten healthy volunteers was aspirated in turn in the six prepared syringes from an *iv* catheter followed immediately by measurement of the ACT (ACTester™, QUEST Medical, Allen, TX, USA). The blood nafamostat concentrations were then 0 mol·L^{-1} and approximately 10^{-7}, 10^{-6}, 5×10^{-6}, 10^{-5} and 5×10^{-5} mol·L^{-1}, respectively.

There was a highly significant relationship between blood nafamostat concentration and ACT. The ACT was prolonged significantly at 5×10^{-6}, 10^{-5} and 5×10^{-5} mol·L^{-1} nafamostat, showing values of 221 ± 74, 300 ± 70 and 665 ± 249 sec, respectively. (Figure).

During hemofiltration, the ACT should be maintained between 180 and 240 sec.[3] These values correspond to an appropriate nafamostat concentration of 0.6 to 1×10^{-5} mol·L^{-1}, suggesting that 10^{-5} mol·L^{-1} is required for blood to pass through the hemofilter safely. In our clinical practice, 0.5 mg·kg^{-1}·hr^{-1} nafamostat is usually injected for CHDF.[2] If the patient weighs 60 kg, 0.5 mg·kg^{-1}·hr^{-1} nafamostat injected into blood flowing at 100 mL·min^{-1} results in a concentration of 10^{-5} mol·L^{-1} nafamostat. As an alternative, nafamostat may be injected continuously to result in a circuit blood concentration of 10^{-5} mol·L^{-1}.

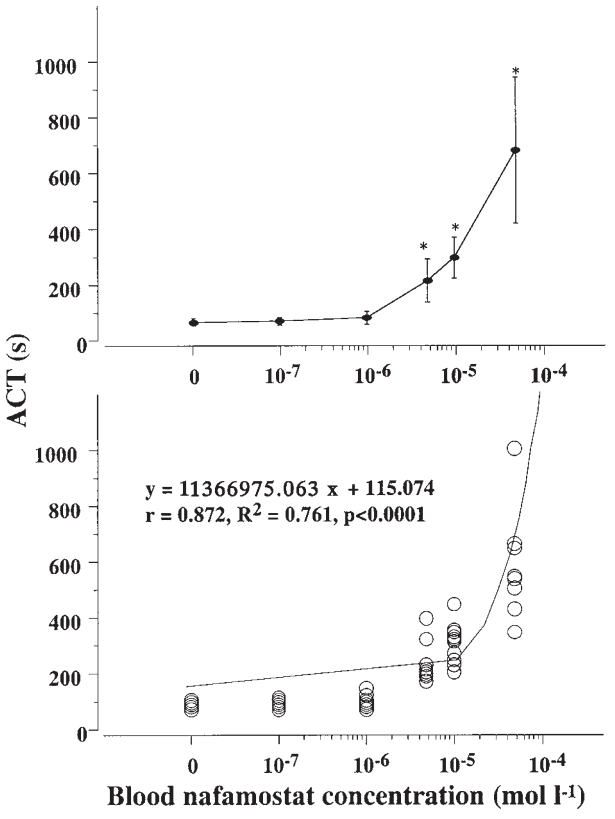

FIGURE The relationship between the blood nafamostat concentration and activated coagulation time (ACT). Upper graph shows values of mean ± SD and statistical changes (*$P < 0.05$ *vs* 0 mol·L^{-1} value). Lower graph shows scattergram and regression equation.

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References

1 *Aoyama T.* Nafamstat mesilate. Drugs of the Future 1984; 9: 747–8.