Hemolysis in Blood Infused under Pressure

STEPHEN EURENIUS, A.B.,* AND ROBERT M. SMITH, M.D.†

During massive transfusions, blood frequently is infused under considerable pressure, often by means of a pneumatic device such as a Fenwal bag at pressures exceeding 300 mm Hg. Question naturally arises as to the danger of hemolysis, especially when needles of smaller caliber may be used during pediatric surgery. It might be assumed that hemolysis, under such circumstances, would increase with increasing age of the banked blood, increasing pressure used, and decreasing bore of the needles. Although the first two assumptions are correct, Moss and Stanton[1] found that due to greater turbulence in needles of larger bore, hemolysis actually increases when blood is forced through larger needles. Because their experiments were conducted under extreme conditions of pressure (150 psi) using freshly drawn heparinized blood, we wished to re-examine the problem under more normal clinical transfusion conditions.

METHOD

Blood was drawn from two healthy male donors with hematocrits of 41 and 43 per cent. It was stored in Fenwal plastic bags with citrate phosphate dextrose (CPD) anticoagulant, at 4 C. Tests were run at zero and seven days after collection with the blood equilibrated at room temperature. The blood was forced through needles of 18, 22, and 26 gauge at driving pressures of 100, 200 and 300 mm Hg delivered by means of a Fenwal bag system. To obtain a controlled pressure the system was modified by incorporation of compressed oxygen. Each test was carried out with triplicate aliquots of 10 ml. The samples were then spun down on an IEC‡ centrifuge at 9,000 × g for 10 minutes. Plasma was then extracted in Pasteur pipettes for hemolysis determinations using the Hanks benzidine method.[2] Readings were made on a Gilford spectrophotometer.

TABLE 1. Hemolysis of Erythrocytes in Fresh Blood (Hct 43 Per Cent, Baseline Hgb 10.9 mg/100 ml)

Needle Bore (g)	Length (Inches)	Driving Pressure (mm Hg)	Plasma Hemoglobin (mg/100 ml)
26	½	100	11.1
26	½	200	12.3
26	½	300	15.0
22	1½	100	11.5
22	1½	200	15.2
22	1½	300	18.4
18	1½	100	15.6
18	1½	200	19.4
18	1½	300	27.5

TABLE 2. Hemolysis of Erythrocytes in Blood Stored Seven Days (Hct 41 Per Cent, Baseline Hgb 22.3 mg/100 ml)

Needle Bore (g)	Length (Inches)	Driving Pressure (mm Hg)	Plasma Hemoglobin (mg/100 ml)
26	½	100	25.9
26	½	200	27.0
26	½	300	32.1
22	1½	100	29.1
22	1½	200	34.3
22	1½	300	38.7
18	1½	100	31.6
18	1½	200	37.8
18	1½	300	44.5

RESULTS

Hemolysis of erythrocytes was found to increase directly with driving pressure and with age of stored blood and, as shown by Moss and Stanton, with increasing needle bore (tables 1 and 2). The most severe of our conditions, 7-day-old blood driven through an 18-gauge needle under 300 mm Hg pressure, produced only 44.5 mg/100 ml of plasma

* Research Fellow, Anesthesiology Labs Department.

† Director of Anesthesiology.

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‡ International Equipment Company, Needham, Mass.

hemoglobin, or an increase of 22.2 mg/100 ml over the seven-day plasma hemoglobin baseline of 22.3 mg/100 ml. Since hemolysis of less than 75 mg/100 ml is not considered to be of clinical significance in causing morbidity or mortality, none of the samples in our tests showed a significant degree of hemolysis.

REFERENCES

1. Moss F, Stanton C: Blood flow, needle size and hemolysis—examining an old wives' tale. N Engl J Med 282:967, 1970
2. Hanks GE, Cassell M, Ray N, et al: Further modification of the benzidine method for measurement of hemoglobin in plasma. J Lab Clin Med 56:486–498, 1960

Persistent Atrial Arrhythmias Associated with Placement of a Swan–Ganz Catheter

DWIGHT G. GEHA, M.D.,* NEVILLE J. DAVIS, M.B.B.S., F.F.A.R.C.S.,† DEMETRIOS G. LAPPAS, M.D.‡

Since the introduction of the Swan-Ganz flow-directed balloon-tipped catheter,[1] bedside monitoring of pulmonary-artery (PA) and pulmonary-capillary-wedge (PCW) pressures has been employed with increasing frequency and safety. Accurate assessment of left-heart filling pressures in patients with myocardial infarction[2] and valvular heart disease with decompensation and fluid replacement in a variety of noncardiac conditions, such as extensive trauma and septicemia, can be carried out. The pulmonary capillary wedge pressure measurement can also be of particular value during the induction of anesthesia and intraoperative management of these patients, as well as those who are less seriously ill, but undergoing extensive surgery with major blood losses or fluid shifts.

Complications have included knotting of the catheter[3] and perforation of the pulmonary artery.[4] Arrhythmias have been encountered, but those reported have been only premature ventricular contractions (PVC's) and, occasionally, runs of multiple PVC's, but not sustained ventricular tachycardia[4] or ventricular fibrillation.[5] The following are case reports of arrhythmias in two patients, atrial fibrillation and atrial flutter with varying block, the only atrial arrhythmias which have been encountered in the placement of 180 Swan-Ganz catheters.

REPORT OF TWO CASES

Patient 1. A 60-year-old man with degenerative arthritis of the right hip was scheduled for total hip replacement under general anesthesia with induced hypotension. Preoperative evaluation disclosed no abnormality and the ECG showed sinus rhythm. Anesthetic premedication was meperidine, 50 mg, promethazine, 25 mg, and scopolamine, 0.3 mg.

Arterial and central venous cannulae were inserted, and while these pressures and the electrocardiogram were continuously monitored, a Swan-Ganz catheter was passed into the right internal jugular vein. Atrial fibrillation occurred when the catheter entered the right atrium (fig. 1A). The ventricular rate was 110/min and blood pressure was 150/80 torr. Anesthesia was then induced, but because the atrial fibrillation continued, the catheter was withdrawn. Forty minutes later, normal sinus rhythm spontaneously returned (fig. 1B). Controlled hypotension was induced with pentolinium, and the operative and postoperative courses were uneventful.

Patient 2. A 42-year-old woman with moderately

* Third-year resident.
† Instructor.
‡ Instructor.

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Address reprint requests to: Dr. D. G. Lappas, Department of Anesthesia, Massachusetts General Hospital, Boston, Massachusetts, 02114.