Hetastarch as a Clear Prime for Cardiopulmonary Bypass

David A. Palanzo, Martin J. O'Neill, Jr., Dennis R. Williams, and Grant V. S. Parr

West Jefferson General Hospital
Marrero, Louisiana

Presbyterian-University of Pennsylvania Medical Center (Dr. Parr)
Philadelphia, Pennsylvania
and
The Milton S. Hershey Medical Center (Dennis Williams)
The Pennsylvania State University
Hershey, Pennsylvania

Abstract

Hydroxyethyl starch, an artificial plasma expander, was investigated for use as a colloidal pump prime for cardiopulmonary bypass. A 3% hetastarch solution was compared with a 4% albumin solution in eighty-four patients undergoing myocardial revascularization. There was no statistical difference in patient population when compared by age, weight, body surface area, bypass time and aortic cross-clamp time. The post-bypass platelet counts were lower in those patients receiving the hetastarch prime, but they were sufficient to maintain normal hemostasis. There were no differences in chest tube drainage, blood products used, plasma hemoglobin, or fibrinogen levels. The albumin prime costs nearly three times as much per patient as the hetastarch prime.

Introduction

Hetastarch (HES), which is a hydroxyethyl-substituted amylopectin that approximates the behavior of albumin, is increasingly being used as a plasma expander. Recent reports have shown that hetastarch is a safe and effective colloidal solution for use in fluid resuscitation for patients in circulatory shock.[1,2,3] Diehl and associates,[4] and Lell and co-workers[5] have used hetastarch in post-operative cardiac patients in place of albumin. We have shown, in a previous study, that a 3% hetastarch solution can be used as a safe, inexpensive and effective replacement for albumin as a colloidal pump prime for patients undergoing cardiac surgery for coronary artery disease.[6] In this prospective study, we investigated and evaluated hetastarch as a prime for cardiopulmonary bypass using a well-defined patient population where the varying parameters between the two groups are negligible.

Materials and Methods

Two cell-free colloidal primes for cardiopulmonary bypass were compared using a group of eighty-four open heart patients undergoing myocardial revascularization. Forty-two patients received a 3% hetastarch (Hespan[a]) prime, while forty-two patients received a 4% albumin solution (Table 1). The patients were matched according to age and body surface area. All emergency cases and patients requiring ventricular assist devices were excluded from the study.

The cardiopulmonary bypass technique was the same for all patients. It included the use of systemic hypothermia to 25°C and induced 4°C, hyperkalemic, crystalloid cardioplegia.[7] The bypass circuit included a Harvey H-1000[b] bubble oxygenator, an Intersept[c] filtered cardiotomy reservoir, and a Pall[d] arterial line filter.

Whole blood or packed red blood cells were administered if the patient's post-operative hematocrit was less than 20 percent. Platelet concentration was given if the post-operative platelet count was less than 100,000 and there were signs of bleeding. Fresh frozen plasma was administered to

Direct communications to: David A. Palanzo, C.C.P., Medical Specialties Building, 4520 Wichers Drive, Suite 203, Marrero, LA 70072.

[a]American Critical Care, American Hospital Supply Corporation, McGaw Park, IL 60085.

[b]William Harvey, C.R. Bard, Inc., Santa Ana, CA 92705.

patients whose cardiopulmonary bypass time was greater than 60 minutes.

TABLE 1

Cardiopulmonary Bypass Pump Primes

Hetastarch Prime

1000 ml. 6% Hetastarch
800 ml. Ringer's Lactate
100 ml. 50% Dextrose
45 mEq. $NaHCO_3$
5000 units Sodium Heparin

Albumin Prime

300 ml. 25% Albumin
1500 ml. Ringer's Lactate
100 ml. 50% Dextrose
45 mEq. $NaHCO_3$
5000 units Sodium Heparin

Bypass time, aortic cross-clamp time, urine output on bypass, platelet counts and fibrinogen levels before and after bypass, blood and blood products used within the first 24 post-operative hours, chest tube drainage at 4 and 24 hours after surgery, post-operative prothrombin and partial thromboplastin times and post-bypass plasma free hemoglobin levels were recorded for all patients. Statistical comparisons were made using the Statistical Analysis System (SAS)[8] on an IBM 3081[e] computer. A p value of less than 0.05 was considered significant. A comparison of the cost of the different priming solutions to the patient was also made between the two groups.

Results

When compared by age, weight, body surface area, bypass time, and aortic cross-clamp time, there was no statistical difference in patient population (Table 2). We found no statistical difference between the urine output on bypass, the pre and post bypass fibrinogen levels, the fibrinogen drop, the partial thromboplastin times, chest tube drainage at 4 and 24 hours post surgery, the amount of blood and blood products used, and the plasma free hemoglobin levels. Similarly, there was no statistical difference in the mean number of vessels bypassed: hetastarch-3.4 vessels, albumin-3.6 vessels.

The only significant differences were that the post-bypass platelet count was lower ($p < 0.008$) and the platelet drop during bypass was higher ($p < 0.01$) in those patients receiving hetastarch, and the prothrombin times were significantly higher ($p < 0.04$) for those patients receiving the albumin prime. In light of no difference in hemostasis between the two groups, these statistically significant differences appear to have no clinical significance.

There was also a difference in the cost of each prime to the patient. The prime containing albumin ($467.00) costs nearly three times as much as the hetastarch prime ($158.00) at our institution.

Discussion

Albumin is continually becoming less available and consequently more expensive. Several artificial plasma expanders have been evaluated to replace albumin. Low and high molecular weight dextran, for example, have been shown to interfere with the function and aggregation of platelets.[9,10] Dextran has also been shown to cause allergic reactions.[9] An alternative plasma expander that does not have these problems is hydroxyethyl starch.

In our experience with patients receiving a 3% hetastarch solution as a cardiopulmonary bypass prime we have not seen any more complications resulting from the prime. The post bypass platelet counts were lower in those patients receiving the hetastarch prime than in those receiving the albumin prime, but they were sufficient to maintain normal hemostasis as evidenced by a lack of difference between the two groups for chest tube drainage and the amount of blood products used. The lower platelet counts oberved in the hetastarch group may be a dilution effect of Hespan.

Even though the prothrombin times for the patients receiving the prime containing albumin (13.1) were significantly higher than for those receiving the hetastarch solution (12.6), they were within normal limits and resulted in no clinical manifestations (Table 2).

In a recently published study, Saunders and colleagues compared patients receiving hydroxyethyl starch with patients receiving albumin as an additive in pump prime solutions.[11] They found comparable changes in coagulation variables be-

[c]1351, Extracorporeal, Inc., King of Prussia, PA 19406.
[d]EC3840, Pall Biomedical Products Corporation, East Hills, N.Y. 11548
[e]International Business Machines Corporation, Atlanta, GA 30055.

TABLE 2

Patient Population Variables Compared Using Albumin Prime ad Hetastarch Prime

Results	Albumin Prime	Hetastarch Prime	Significance
No. of patients	42	42	
Age (yr)	56.7 ± 10.1	56.5 ± 8.3	NS
Weight (kg)	83.9 ± 12.8	81.5 ± 12.3	NS
Body surface area (m^2)	1.97 ± 0.17	1.90 ± 0.17	NS
Bypass time (min)	99 ± 34	92 ± 28	NS
Aortic cross-clamp time	62 ± 23	56 ± 20	NS
Urine output on bypass (ml)	348 ± 278	421 ± 312	NS
Fibrinogen			
Pre-bypass	262 ± 78.7	263 ± 75.6	NS
Post-bypass	157 ± 42.3	155 ± 53.0	NS
Drop	0.40 ± 0.11	0.41 ± 0.14	NS
Platelet count (X1,000)			
Pre-bypass	201 ± 51.7	194 ± 42.3	NS
Post-bypass	149 ± 48.0	124 ± 35.0	$p < 0.008$
Drop	0.26 ± 0.17	0.36 ± 0.18	$p < 0.01$
Chest tube drainage			
At 4 hr	306 ± 215	283 ± 164	NS
At 24 hr	886 ± 403	746 ± 285	NS
Prothrombin time (sec)	13.1 ± 1.05	12.6 ± 1.18	$p < 0.04$
Partial thromboplastin time	38.3 ± 5.0	38.0 ± 4.6	NS
Plasma hemoglobin (mg/dl)	21.4 ± 13.1	21.4 ± 24.9	NS
Plasma hemoglobin per min of bypass	0.22 ± 0.10	0.24 ± 0.27	NS
Blood usage (units)			
Bypass	0.6 ± 0.9	1.0 ± 1.0	NS
Total (24 hr)	3.4 ± 1.8	3.7 ± 2.0	NS
Fresh frozen plasma (24 hr)	1.0 ± 1.5	0.6 ± 1.1	NS
Platelets (24 hr)	1.6 ± 3.3	0.7 ± 2.0	NS

NS = Not significant.

tween the two groups with slightly poorer platelet aggregation in the albumin group.

From our investigation of hetastarch as a colloidal prime for cardiopulmonary bypass, we find it an inexpensive, safe, and effective replacement for albumin.

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