A Clinical Evaluation of the Correlation and Reprodicibility Of Three Automated Devices For Measurement of Activated Clotting Times

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Abstract

The Activated Clotting Time (ACT) assumes an important role in documentation of adequacy of perfusion. Therefore, it is important to document the correlation and reproducibility of automated systems currently available to measure the ACT value. During surgical procedures of 37 patients requiring cardiopulmonary bypass a blood sample was drawn in a single syringe and ACT values obtained using four Hemotec ACTs (T-ACT), four Hemochron ACTs (M-ACT), and two Sonoclot ACTs (S-ACT). Sample points with the mean of two of the three sets of ACTs exceeding 650 were excluded and the values were divided into heparinized (ACTH) (n=44) and nonheparinized (ACTN) (n=58) groups.

Group	Mean Value	Avg. Std. Dev.	r 2/ T-ACTN	r w/ H-ACTN	r w/ T-ACTH	r w/ H-ACTH
T-ACTN	104	3	-	.638	-	-
H-ACTN	128	5	.638	-	-	-
S-ACTN	138	11	.663	.580	-	-
T-ACTH	551	48	-	-	-	.224
M-ACTH	514	69	-	-	.224	-
S-ACTH	768	98	-	-	.041	.244

The very poor correlation of the three systems raises doubts as to interchangeability of ACT values from each system. The reproducibility (based on the size of the STD. DEV.) of the Hemotec system is significantly better than the Sonoclot.

Introduction

The Activated Clotting Time (ACT) assumes an important role in the documentation of the adequacy of perfusion (1, 2). The establishment of suggested ACT levels for cardiac surgery utilizing cardiopulmonary bypass requires documentation of the interchangeability of different methods of measurement (3, 4, 5). Differences in the method of detection of clot formation and the activator employed by three automated ACT systems raise questions as to deviation in the reproducibility of each system and the correlation of values obtained from the different systems. An evaluation was performed on heparinized and nonheparinized patients during normothermia and hypothermia to provide data over the full range of clinical circumstances. Specimens for the different systems were obtained from a single sample at each time point to allow for paired observations and eliminate the variables of temperature, heparin level and potency, patient variance, and hemodilution (5, 6, 7). The evaluation was undertaken to provide an objective study of the reproducibility and correlation of the ACT value obtained from three automated ACT systems.

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Methods and Materials

A prospective study of ACT values for thirty seven patients requiring extracorporeal circulation for cardiac surgery was undertaken. Two recently calibrated systems were obtained from each manufacturer (Hemochron 800 (a), Hemotec ACT Analyzer (b) and the Sonoclot Analyzer (c)) and disposable supplies purchased. To allow for an indication of the reproducibility of each individual system four individual tubes or cartridges were used for the Hemochron and Hemotec systems and two cups for the Sonoclots at each time point. Blood samples of 10 mls. were drawn from the arterial line following removal of seven mls. of waste to provide pre-heparinization, post heparinization - prepump, and post protamine samples. Samples of 10 ml.s were removed from the bleed line of the arterial filter following a seven ml flush to provide samples during the bypass run. Two mls of blood were placed in each of the four Hemochron ACT tubes with the machine timers being activated just prior to injection of the blood into the tube. The Hemochron tubes were slowly tilted back and forth 10 times and then placed in the test well of the appropriate Hemochron. The tube was gently turned until the detector light was activated. All of the Hemochron tubes used were prewarmed, prior to injection of the sample, to 37°Celsius.

a. International Technidyne, Edison, NJ 08820
b. Hemotec, Englewood, CO 80112
c. Sienco, Inc., Morrison, CO 80465

Each of the Hemotec cartridges was prewarmed in the Hemotec ACT machine and shaken to provide dispersal of the activator prior to infusion of an appropriate volume of blood into each of the chambers. Hemotec's low range cartridges were used for nonheparinized patients and high range cartridges for heparinized patients as suggested by the manufacturer. The cartridges were then placed into the Hemotec ACT system and the cover pulled forward to activate the system. The cups for the Sonoclot system were prewarmed in the instruments heating block and the activator in each cup was stirred prior to blood infusion to facilitate dispersion of the activator. Two tenths of a cc of blood were added to each cup and the mix mode activated. Following completion of the mix cycle, the probe was lowered into the sample cup. The recorder was activated at the time of infusion of the blood into the cup and positioned after the probe was lowered into the blood. The ACT value was obtained by measuring the time to a 1% rise in the y axis of the graph. The values from each cartridge of the different systems were recorded at each time point and the mean value and standard deviation for each system calculated. The data points where at least two of the three systems average value exceeded 650 seconds were eliminated due to the poor reproducibility of the ACT test above 600 seconds and the data was separated into heparinized and nonheparinized groups for data analysis. The r-coefficient was calculated for the mean ACT from each system at each time point for both the heparinized and the nonheparinized groups. The mean value of the standard deviation for each system at each time point was also calculated as well as the average value for each system for both heparinized and nonheparinized groups. The values of the average standard deviations for the different systems were analyzed using a student T-test for significance.

Results

The average ACT value of the three systems in both the heparinized and the nonheparinized categories were significantly different ($p < .05$) (Table 1 and 2). The mean value of the standard deviation at each time point was significantly

TABLE 1: Average Act Value in Seconds

Group	Hemotec	Hemochron	Sonoclot
Nonheparinized	104	128	138
Heparinized	551	514	768

TABLE 2: Value of the Student T-Test for Average ACT Value

Group	Nonheparinized	Heparinized
Hemotec - Hemochron	.000	.02
Hemotec - Sonoclot	.000	.000
Hemochron - Sonoclot	.041	.000

different ($p < .05$) for the Hemotec versus the Sonoclot and the Hemchron versus the Sonoclot system in the nonheparinized group. The mean value of the standard deviation at each time point was significantly different ($p < .05$) for the Hemotec versus the Sonoclot system in the heparinized group. (Table 3 and 4.) The correlation coefficients for the mean ACT value at each point between the systems in the nonheparinized group were low and in the heparinized group were extremely low. (Table 5, Graphs 1-6.)

TABLE 3: Mean of the Standard Deviation at Each Time Point

Group	Hemotec	Hemochron	Sonoclot
Nonheparinized	3	5	11
Heparinized	48	69	98

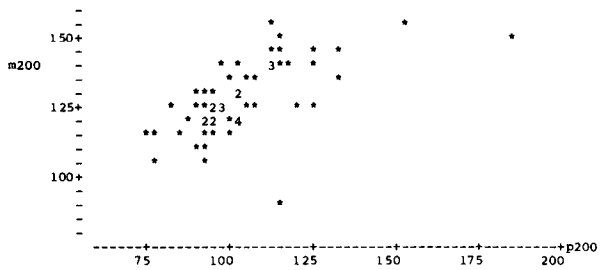
TABLE 4: Value of the Student T-Test for the Mean of the Standard Deviation at Each Time Point

Group	Nonheparinized	Heparinized
Hemotec - Hemochron	.12	.055
Hemotec - Sonoclot	.001	.009
Hemochron - Sonoclot	.006	.11

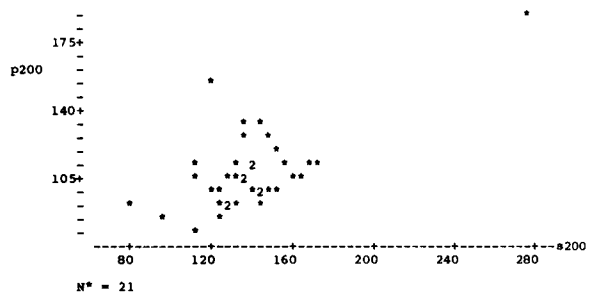
TABLE 5: Correlation Coefficient of the Mean ACT at Each Time Point

Group	Nonheparinized	Heparinized
Hemotec - Hemochron	.638	.224
Hemotec - Sonoclot	.663	.041
Hemochron - Sonoclot	.580	.244

GRAPH 1: ACT Values for Nonheparinized Patients Hemochron (M200) vs. Hemotec (P200) r = .638



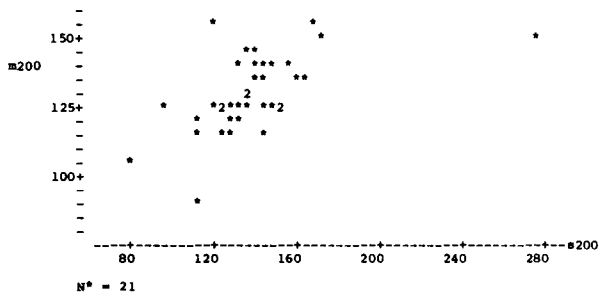
GRAPH 2: ACT Values for Nonheparinized Patients Hemotec (P200) vs. Sonoclot (S200) r = .663



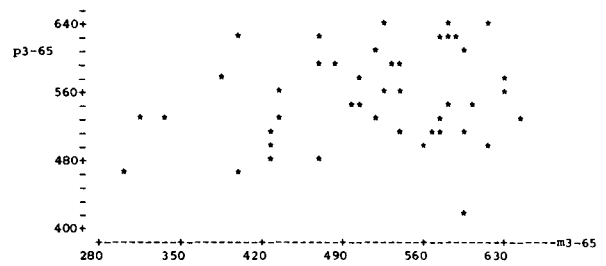
Discussion

The use of the ACT value as an indicator of adequacy of perfusion raises a question as to the correlation of different techniques and activators used in the measurement of the value. An ACT value of greater than 400 seconds has been related to

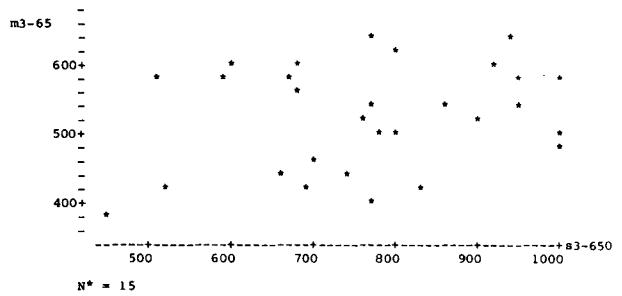
GRAPH 3: ACT Values for Nonheparinized Patients Hemochron (M200) vs. Sonoclot (S200) r= .580



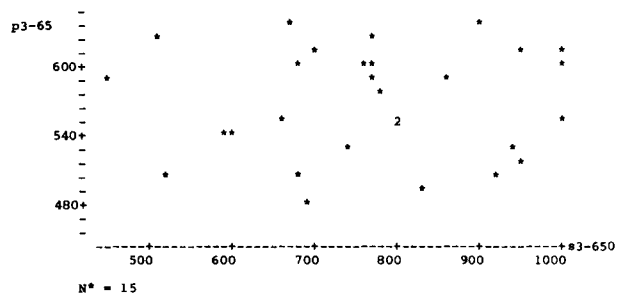
GRAPH 4: ACT Values for Heparinized Patients Hemotec (P3-65) vs. Hemochron (M3-65) r= .224



GRAPH 5: ACT Values for Heparinized Patients Hemochron (M3-65) vs. Sonoclot (S3-650) r= .244



GRAPH 6: ACT Values for Heparinized Patients Hemotec (P3-65) vs. Sonoclot (S3-650) r= .041



lack of formation of fibrin monomers, no consumption of clotting factors, or lack of fibrin deposits in the cardiopulmonary bypass circuit and suggested as a minimum safe level (3, 4). The significant differences in the mean ACT value and the poor correlation of the ACT value between the three systems casts serious doubts on the interchangeability of ACT values from the different systems. Differences in the method of detection of clot formation between systems (Hemochron-displacement of a rolling magnet from a detector, Hemotec-rate of descent of a plunger, Sonoclot-viscoelasticity) or use of a different activator (Hemochron and Sonoclot-diatomaceous earth and Hemotec-Kaolin) may explain the wide variance in ACT values from the different systems. The lack of conformity necessitates documentation of the system used whenever ACT values are reported and suggests the need for further documentation of minimum ACT levels for the particular systems. The Hemochron and Hemotec systems provided significantly better reproducibility than the Sonoclot system in the nonheparinized category possibly due to the difficulty of determination of short time intervals from the graphic display utilized by the Sonoclot unit. The reproducibility of Hemotec unit was significantly better than the Sonoclot unit in the heparinized category and can possibly be attributed to the difference in uniformity of the activator or to the decreased sampling rate of the Hemotec system above the 200 second mark. The large deviation seen even within systems on a single blood sample illustrates the inaccuracies of the test as previously reported by Sillick et al. (8). The acceptable ACT value for a particular system should allow for the degree of variance of the system.

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