

Avoiding Heparinization of Arterial Line and Maintaining Acceptable Arterial Waveform After Cardiac Surgery: A Randomized Clinical Trial

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Background: Invasive and continuous blood pressure (BP) monitoring is crucial after cardiac surgery. Accuracy of BP measurement mostly depends on patency of arterial catheter and acceptable waveform. Heparinized saline flush usually used for this purpose may be accompanied by potential heparin adverse effects.

Objectives: The aim of this study was to compare heparinized and non-heparinized saline flush to maintain acceptable arterial waveform after cardiac surgery.

Materials and Methods: In a double blind randomized trial study, 100 patients undergoing elective cardiac surgery were randomized to using heparinized (n = 50) or non-heparinized (normal) saline flush (n = 50) to maintain patency of arterial catheter after operation. Indwelling arterial catheters were checked daily for acceptable arterial waveform for three days as primary outcome measures.

Results: Frequency of acceptable arterial waveform ranged from 66% to 80%, in first, second and third postoperative days. There were no statistically significant differences between heparinized and non-heparinized saline groups regarding acceptable arterial waveforms in all the three postoperative days (all P values > 0.05).

Conclusions: Using non-heparinized normal saline is suitable to maintain acceptable arterial waveform for short-term (three days) after adult cardiac surgery considering potential adverse effects of heparin.

Keywords: Heparin; Saline Solution; Cardiac Surgery

1. Background

Cardiac surgery is increasingly performed for high-risk patients referred for operation; much attempts have been performed to reduce the operative mortality (1). Hemodynamic monitoring is necessary in cardiac intensive care unit. Since invasive hemodynamic monitoring provides continuously monitoring such as showing the curves continuously with more accuracy, it would be preferable to noninvasive methods (2, 3). Invasive hemodynamic monitoring is more costly, has more complications and requires more skill to perform and maintain a monitoring than non-invasive monitoring, also is acceptable as a standard method for monitoring critical patients (4). Arterial catheters are used for continuous monitoring of critical patients in intensive care units (5).

Arterial catheterization complications include inappropriate arterial waveform, bleeding, local hematoma and temporary occlusion of the arteries, sustained ischemic injury, pseudo-aneurysm and infection (6). Arterial thrombosis is the main complication of arterial catheterization (7). To obtain the correct data, transducer should be at the level of fourth intercostal space (8). In addition,

zero the system is to neutralize the effect of hydrostatic pressure, transducer pressure, amplifier and oscilloscope (9).

Normal arterial waveform contains the following components: Ascending slope of systolic arterial pressure, peak systolic arterial pressure, descending slope of systolic arterial pressure, dicrotic notch, continue of blood flow through the artery to the vein based on the pressure gradient and end-diastolic pressure (5). Heparinized saline solution is widely used to prevent occlusion of arterial catheters in intensive care units (10). Heparin has effects at multiple sites of the intrinsic and extrinsic coagulation pathways. The most common complication of heparin is bleeding (11). Unfractionated heparin is used as a standard anticoagulant in patients undergoing cardiac surgeries (12). Evidence shows that chronic use of heparin, even at low dose, may cause thrombocytopenia and bleeding (13, 14). Recent evidence suggests that normal saline solution can maintain patency of arterial catheter, increase accuracy of coagulation tests and prevent patient from exposure to complications of heparin (10).

2. Objectives

The aim of this study was to compare heparinized and non-heparinized normal saline flush to maintain acceptable arterial waveform in indwelling arterial catheters after adult cardiac surgery including coronary bypass and valve operations.

3. Materials and Methods

In a double blind randomized clinical trial study, 100 patients undergoing elective cardiac surgery entered the study. The study was approved in institutional ethic committee and all patients filled out informed consents. The patients were randomized to use heparinized (n = 50) or non-heparinized (normal) saline flush (n = 50) to maintain patency of arterial catheter after operation. The randomization method was simple and random allocation was performed using an online method (URL:<http://www.graphpad.com/quickcalcs/randomize2/>). The random allocation was concealed from researcher and kept confidential with third person until the end of study. The study flow diagram is shown in Figure 1. Inclusion criteria were patients who had arterial catheters, PT (prothrombin time) up to 13 seconds, activated partial prothrombin time (aPTT) up to 45 seconds, platelet count

140000 - 440000 mm³, filling out a consent form for the study and placement of catheters in intensive care unit. Exclusion criteria were known allergy to heparin, history of heparin-induced thrombocytopenia, coagulation disorder before using heparin, more than five times effort to put the catheter in place, thrombocytopenia with platelets less than 100000 mm³ and simultaneous participation in any other study.

For the survey of arterial waveform, monitoring devices were connected to the patient. Arterial catheters should have positive response to the flush test. This means that with the serum flush in the arterial catheter, arterial wave disappeared and a direct line appeared in the monitoring device. Closing the catheter should also have a rapid decline to below the baseline. Flush test can determine damping situation in system. This means normal damped, over damped and under damped, in which in any situation with response to the flush test, pressure increases in the system, but reaction in the end of flush test is varied. In the normal damped system at end of flush test, there would be one to two oscillation. In the over damped system, at the end of flush test there is no oscillation and with under damped system, there would be several oscillation at the end of flush test on the oscilloscope.

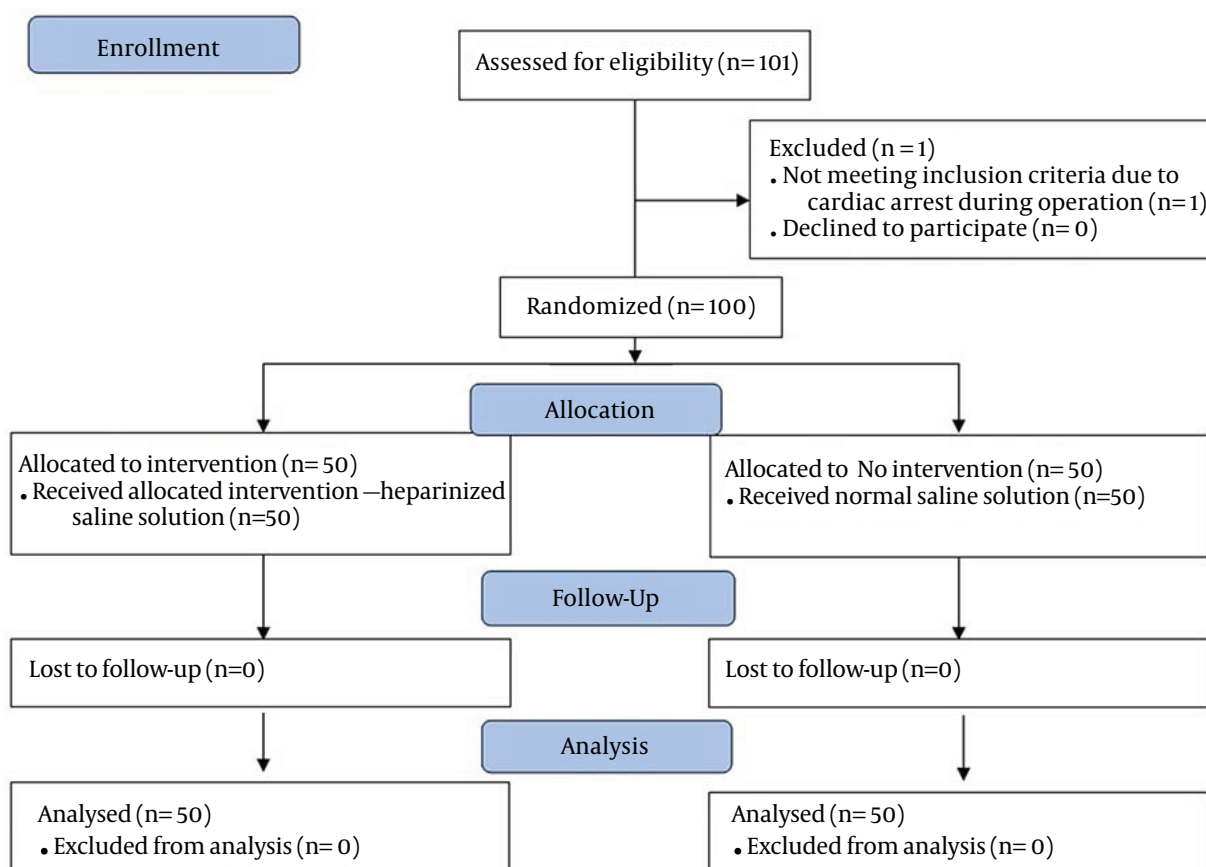


Figure 1. The Study Flow Diagram

Our data gathered daily and repeated for three days. In the heparinized saline group to remain patency of catheters, heparin with concentration of 10 u/mL was used. In the normal saline group, 5 mL of normal saline was used for each flush.

The collected data was analyzed using SPSS v.21.0 statistical software (SPSS Inc. Chicago, IL, USA). Categorical data analyzed using chi-square or Fisher's exact test as appropriate. Mean values of continuous parameters compared between the two groups using independent samples t-test. P value ≤ 0.05 was considered statistically significant in this study.

4. Results

Of 100 studied patients, 69 were men and 31 women. All patients completed the study. Patients' demographic and

clinical data are summarized in Table 1. As Table 1 shows, mean of aPTT tests and platelet count were comparable in heparinized and non-heparinized normal saline flush groups. Most commonly used arterial catheter size was 20 gauges and most common catheterization site was radial artery.

As Table 2 demonstrates, frequency of acceptable arterial waveform ranged from 66% to 80%, in first, second and third postoperative days. There were no statistically significant differences between the heparinized and non-heparinized saline groups regarding acceptable arterial waveforms in all the three postoperative days (all P values > 0.05). Repeated measures ANOVA test showed statistically significant changes during consecutive three postoperative days in frequency of acceptable arterial waveform in each study group ($P < 0.05$).

Table 1. Demographic and Clinical Characteristics of Patients in the Two Study Groups ^{a,b,c}

Parameters	Heparinized Saline Group (n = 50)	Normal Saline Group (n = 50)	P Value
Age, y	49.7 \pm 11.2	53.5 \pm 12.2	0.194
Gender			
Male	30 (60)	39 (78)	0.052
Female	20 (40)	11 (22)	
Height, cm	162 \pm 14	160 \pm 15	0.492
Weight, kg	69.1 \pm 11.1	67.4 \pm 10.8	0.440
Type of surgery			
CABG	33 (66)	27 (54)	0.710
Valve	22 (44)	28 (56)	
aPTT, sec ^c	33.7 \pm 4.9	32.1 \pm 4.2	0.083
Platelet count, $\times 10^3$ ^c	226 \pm 51	240 \pm 57	0.199
Arterial catheter size (gauge)			
20	46 (92)	48 (96)	0.678
18	4 (8)	2 (4)	
Arterial catheter site			
Radial	42 (84)	41 (82)	
Brachial	5 (10)	6 (12)	
Femoral	2 (4)	0	0.791

^a Abbreviations: aPTT, Activated partial prothrombin time; and CABG, Coronary artery bypass grafting.

^b Data are presented as No. (%) or Mean \pm SD.

^c In second postoperative day.

Table 2. Frequency of Acceptable Arterial Waveform in First, Second and Third Postoperative Days ^a

Variable	Heparinized Saline Group (n = 50)	Normal Saline Group (n = 50)	P Value
Acceptable arterial waveform in 1st postop Day	39 (78)	36 (72)	0.774
Acceptable arterial waveform in 2nd postop Day	40 (80)	39 (78)	0.793
Acceptable arterial waveform in 3rd postop Day	33 (66)	32 (65.3)	0.887

^a Data are presented as No. (%).

There was one case of arterial occlusion in radial artery during three postoperative days in each study groups, needed to change the catheter place and indwelling arterial catheter in other radial side.

5. Discussion

Heparinized saline solution is known as a common solution in maintaining catheter patency and effectiveness (13). However, adverse effects of heparinized saline solution and effect of normal saline in maintaining patency of arterial catheter lead to controversy over the type of flush solutions to maintain catheter effectiveness (10, 15-17). In a recent systematic review, Kordzadeh et al. (15) concluded that heparinized saline solution may be better for long-term use of arterial line. Use of heparin, even in low dose, can be associated with potential complications such as heparin induced thrombocytopenia (13). In addition, use of heparin in flush solution can increase aPTT significantly (5). Therefore, our aim was to determine the effect of heparinized saline and normal saline solution to provide acceptable arterial waveform for short-term maintenance. Our study showed that acceptable arterial waveforms in heparinized saline and normal saline groups in the first, second and third days were not statistically different.

Normal saline provided acceptable arterial waveform and regarding heparin complications such as bleeding, thrombosis and thrombocytopenia, we suggest to use normal saline solution as an effective alternative solution for heparinized saline solution. In conclusion, normal saline solution can be used as a safe alternative for heparinized saline solution for short-term after adult cardiac surgery.

5.1. Limitations

One of the limitations in this study was patient population (adult cardiac surgery), so these results could not be generalizable to other patient population. This trial was performed on limited sample size (n = 100) and in a single center base; large scale multicenter studies could be more powerful. As our patients' stay were limited to 3-4 days in ICU, we assessed the arterial waveform only for three days; for evaluation of efficacy of normal saline on long-term arterial waveform, more research must be performed in ICU with long-term patient stay.

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