

ORIGINAL RESEARCH



Effects of immediate and delayed infusion of residual physical blood on coagulation function, intraoperative bleeding, and hemostasis time in aortic dissection surgery under cardiopulmonary bypass

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Abstract

This study aims to assess the differences in coagulation function, intraoperative bleeding and hemostasis time resulting from immediate versus delayed infusion of residual physical blood in patients undergoing cardiopulmonary bypass for aortic dissection. From January 2018 to January 2021, the data of 122 patients diagnosed with acute Stanford type A aortic dissection and treated at Taihe Hospital Affiliated Hospital of Hubei University of Medicine were retrieved and assessed. They were then divided into two groups according to different treatments: a research group and a control group. The research group received a delayed infusion of residual physical blood intraoperatively, while the control group underwent immediate infusion. Various indicators of coagulation, encompassing activated partial thromboplastin time, prothrombin time, thrombin time, and fibrinogen levels, along with hemoglobin levels, utilization of blood products such as red cell suspension, plasma, platelets, and cryoprecipitate, as well as the volume of bleeding, total fluid intake and output, and durations of hemostasis, surgery, and anesthesia, were compared between the two groups. After surgery, coagulation and hemoglobin levels, which were initially similar between the two groups, were found to be significantly improved, with the research group showing superior outcomes ($p < 0.05$). Additionally, patients in the research group required significantly fewer blood products, experienced reduced bleeding and total body fluid exchange and had markedly shorter durations of hemostasis, surgery and anesthesia compared to those in the control group ($p < 0.05$). Pre-infusion adjustment of coagulation function before residual whole blood infusion effectively improves coagulation, reduces bleeding and fluid imbalance, and shortens hemostasis time during aortic dissection surgery with cardiopulmonary bypass. This approach not only reduces transfusion-related risks and improves postoperative recovery but also plays a significant role in optimizing blood management.

Keywords

Cardiopulmonary bypass; Aortic dissection surgery; Immediate infusion; Delayed infusion; Intraoperative hemorrhage; Hemostasis time

1. Introduction

Aortic dissection, resulting from lesions rupturing in the middle layer of the aortic wall, presents a significant clinical challenge [1–3], which leads to blood flow within the middle layer and the separation of the tunica media, leading to the division between the true and false lumens of the aortic wall [4–6]. This condition poses a substantial risk as it affects the aorta, a critical artery responsible for oxygen-rich blood distribution throughout the body. Typically, aortic dissection manifests as severe chest pain, potentially radiating to the back, neck, or abdomen. If left untreated, it can escalate, resulting in life-

threatening complications such as massive bleeding and shock.

Moreover, aortic dissection may obstruct branch arteries, causing organ ischemia and subsequent functional impairments. Additionally, it can disrupt heart function, leading to complications like arrhythmias and heart failure. Acute Stanford type A aortic dissection, primarily involving the proximal aorta, accounts for over 66% of cases and necessitates surgical intervention with cardiopulmonary bypass support as the standard treatment [7–9]. However, clinical research has demonstrated that circulatory shutdown at low temperatures could significantly impair patients' coagulation function during this procedure [10–12].

Therefore, effectively regulating coagulation function during surgery to ensure hemostasis is a critical step for successful outcomes.

In response to this challenge, we proposed adjusting patients' coagulation function followed by delayed transfusion of residual physical blood during aortic dissection under cardiopulmonary bypass based on our hospital's clinical practice experience [13–15]. To further evaluate the effects of immediate versus delayed infusion of residual physical blood on coagulation function, intraoperative bleeding and hemostasis time in aortic dissection surgery under cardiopulmonary bypass, this study retrospectively analyzed the clinical data of 122 patients with acute Stanford type A aortic dissection treated at Taihe Hospital from January 2018 to January 2022 and compared the clinical effects of residual physical blood infusion at different time points.

2. Materials and methods

2.1 Clinical information

This retrospective study comprised 122 patients diagnosed with acute Stanford type A aortic coarctation who were admitted to the Taihe Hospital Affiliated Hospital of Hubei University of Medicine between January 2020 and January 2021. They were distributed into a research and control group according to different treatments, with the former receiving delayed infusion and the latter undergoing immediate infusion of residual physical blood intraoperatively.

Inclusion criteria: (1) meeting the clinical diagnostic criteria for acute Stanford type A aortic coarctation; (2) age: over 18 years; (3) meeting clinical indications for surgery; and (4) providing signed informed consent forms.

Exclusion criteria: (1) patients with abnormal coagulation function; (2) patients with abnormal hemodynamic index; (3) patients with combined abnormal liver and kidney function; and (4) patients with cardiac arrest.

2.2 Clinical management

Patients underwent aortic dissection surgery under cardiopulmonary bypass performed by the same team of surgeons.

Control group (Immediate infusion): After the shutdown of cardiopulmonary bypass, the patients were immediately given an infusion of residual physical blood, followed by coagulation factor, human prothrombin complex, human fibrinogen, platelet, fresh frozen plasma and banked blood.

Research group (Delayed infusion: After giving the patient coagulation stabilization intervention, transfusion of the remaining blood was initiated): After the shutdown of cardiopulmonary bypass, the patients were first given coagulation factor, human prothrombin complex, human fibrinogen, platelet, fresh frozen plasma and banked blood, followed by infusion of residual physical blood when the indicators of coagulation function were gradually stabilized.

2.3 Observational targets

The coagulation indicators in this study included activated partial thromboplastin time, prothrombin time, thrombin time,

and fibrinogen, as well as hemoglobin levels, utilization of blood products including red cell suspension, plasma, platelets and cryoprecipitate, amount of bleeding, total inflow and outflow of body fluids, and durations of hemostasis, operation, and anesthesia, were observed and compared between the two groups before and after surgery.

2.4 Statistics

Data were analyzed using SPSS 22.0 software (IBM Armonk, New York, NY, USA). Quantitative data following a normal distribution are presented as mean \pm standard deviation (mean \pm SD), and *t*-test was used to compare the two groups. For quantitative data not following a normal distribution, median and interquartile ranges were reported, and the Mann-Whitney U test was utilized. Continuous data are provided using frequencies and percentages, with Fisher's exact test and chi-square test applied accordingly. A significance level of $p < 0.05$ was considered statistically significant.

3. Results

3.1 Comparison of clinical data between the two groups

Among the 122 patients with acute Stanford type A aortic coarctation, 97 were male and 25 were female, with ages ranging from 48 to 60 years. The mean age was 53.19 ± 2.12 years, and the BMI (Body Mass Index) ranged from 22.1 to 27.88 kg/m², with a mean BMI of 25.17 ± 1.22 kg/m². The mean systolic blood pressure was 117.98 ± 7.60 mmHg, the mean diastolic blood pressure was 59.61 ± 2.17 mmHg, and the mean heart rate was 83.61 ± 3.13 beats/min. The patients were divided into study and control groups according to different treatments, each consisting of 61 patients. Before surgery, we found no statistically significant differences ($p > 0.05$) in activated partial thromboplastin time, prothrombin time, thrombin time and fibrinogen levels between the two groups. However, after surgery, both groups showed decreased activated partial thromboplastin time, prothrombin time and thrombin time compared to preoperative levels, and fibrinogen levels were also lower postoperatively in both groups, with statistically significant differences ($p < 0.05$) observed. Additionally, postoperatively, the study group exhibited lower activated partial thromboplastin time, prothrombin time and thrombin time compared to the control group, and fibrinogen levels were lower in the study group compared to the control group, with the results being statistically significant ($p < 0.05$) noted. Table 1 presents the detailed findings.

3.2 Comparisons of the indicators of coagulation function between groups

The coagulation function indicators, initially comparable between the two groups before surgery, significantly improved postoperatively, with the research group demonstrating superior outcomes ($p < 0.05$) (Table 2).

TABLE 1. Comparison of clinical data between the two groups.

Groups	N	Sex (Male/Female, n)	Age (yr)	BMI (kg/m ²)	Systolic pressure (mmHg)	Diastolic pressure (mmHg)	Heart rate (times/min)
Study group	61	48/13	53.16 ± 2.16	25.16 ± 1.25	118.05 ± 7.17	59.95 ± 2.16	83.16 ± 3.14
Control group	61	49/12	53.21 ± 2.09	25.19 ± 1.21	117.90 ± 8.06	60.18 ± 2.04	84.05 ± 3.09
<i>t</i> / χ^2 value	—	0.050	0.130	0.135	0.109	0.605	1.578
<i>p</i> value	—	0.823	0.897	0.893	0.914	0.547	0.117

BMI: Body Mass Index.

TABLE 2. Comparisons of the indicators of coagulation function between groups ($\bar{x} \pm s$).

Group	Research group	Control group	<i>t</i> value	<i>p</i> value
N	61	61	-	-
Activated partial thromboplastin time (s)				
Pre-operation	32.41 ± 1.24	32.09 ± 1.16	1.4719	0.1437
Post-operation	33.56 ± 1.25	34.34 ± 1.04	3.7465	0.0003
<i>t</i> value	5.1012	11.2796	-	-
<i>p</i> value	<0.0001	<0.0001	-	-
Prothrombin time (s)				
Pre-operation	13.16 ± 0.35	13.07 ± 0.34	1.4405	0.1523
Post-operation	13.41 ± 0.51	13.96 ± 0.41	6.5645	<0.0001
<i>t</i> value	3.1567	13.0504	-	-
<i>p</i> value	0.0020	<0.0001	-	-
Thrombin time (s)				
Pre-operation	22.84 ± 0.29	22.51 ± 0.31	5.5196	<0.0001
Post-operation	22.71 ± 0.36	23.14 ± 0.32	6.9725	<0.0001
<i>t</i> value	2.1964	11.0440	-	-
<i>p</i> value	0.0300	<0.0001	-	-
Fibrinogen (g/L)				
Pre-operation	3.34 ± 0.08	3.36 ± 0.07	1.4695	0.1443
Post-operation	2.73 ± 0.04	3.28 ± 0.09	43.6156	<0.0001
<i>t</i> value	53.2660	5.4800	-	-
<i>p</i> value	<0.0001	<0.0001	-	-

3.3 Comparisons of hemoglobin between groups

Preoperative hemoglobin levels were similar between the two groups. Postoperatively, while both groups experienced a decrease, the reduction in hemoglobin levels was significantly lower in the research group compared to the control group ($p < 0.05$) (Table 3).

3.4 Comparisons of the usage of blood products between groups

Herein, the results showed that patients from the research group required significantly fewer blood products compared to the control group ($p < 0.05$) (Table 4).

3.5 Comparisons of bleeding and total inflow and outflow of body fluids between groups

Moreover, the research group exhibited significantly reduced amounts of bleeding and total inflow and outflow of body fluids compared to the control group ($p < 0.05$) (Table 4).

3.6 Comparisons of the operative time between groups

Further analysis showed that the research group had significantly shorter durations of hemostasis, surgery and anesthesia compared to the control group ($p < 0.05$). The detailed results are shown in Table 5.

TABLE 3. Comparisons of hemoglobin between groups ($\bar{x} \pm s$).

Group	N	Hemoglobin (g/L)			
		Pre-operation	Post-operation	<i>t</i> value	<i>p</i> value
Research group	61	112.04 ± 6.15	101.25 ± 5.16	10.4974	<0.0001
Control group	61	113.24 ± 6.24	98.35 ± 1.25	18.2739	<0.0001
<i>t</i> value	—	1.0697	4.2661	—	—
<i>p</i> value	—	0.2869	<0.0001	—	—

TABLE 4. Comparisons of the usage of blood products, bleeding, and the flow of body fluids between groups ($\bar{x} \pm s$).

Group	N	Red cell suspension (U)	Plasma (mL)	Platelet (U)	Cryoprecipitate (U)	Amount of bleeding (mL)	Amount of total inflow (mL)	Amount of total outflow (mL)
Research group	61	6.20 ± 0.48	400.15 ± 11.66	15.03 ± 0.80	17.11 ± 0.84	1200.13 ± 34.23	7091.25 ± 200.41	6415.23 ± 156.24
Control group	61	8.00 ± 0.41	575.23 ± 12.35	20.15 ± 0.91	18.92 ± 0.86	2015.34 ± 68.32	7612.61 ± 198.34	7016.23 ± 121.67
<i>t</i> value	—	27.9315	80.5091	33.0033	11.7592	83.3208	14.4415	23.7037
<i>p</i> value	—	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

TABLE 5. Comparisons of the operative time between groups ($\bar{x} \pm s$).

Group	N	Hemostasis time (min)	Operation time (min)	Anesthesia time (min)
Research group	61	114.25 ± 11.25	438.15 ± 22.15	498.34 ± 36.35
Control group	61	161.41 ± 11.65	489.23 ± 23.54	541.25 ± 34.14
<i>t</i> value	—	22.7432	12.3427	6.7204
<i>p</i> value	—	<0.0001	<0.0001	<0.0001

4. Discussion

Clinical case data indicate that alterations in coagulation function recovery can occur in patients undergoing aortic dissection surgery with cardiopulmonary bypass support, attributed to operative procedures, circulatory shutdown at medium and low temperatures, and duration of cardiopulmonary bypass [16–18]. Abnormal coagulation function not only increases the use of blood products during surgery but could also pose a direct threat to the patient's life and health, particularly in severe cases. Thus, improving coagulation function in patients undergoing aortic dissection surgery with cardiopulmonary bypass, thereby reducing hemostasis time and bleeding, presents a challenging task for clinicians [19–21].

Based on our hospital's practical experience and previous clinical reports, we've noticed distinct differences in patients' coagulation function during aortic dissection surgery with cardiopulmonary bypass, particularly when it comes to the timing of residual physical blood infusion—whether immediate or delayed. These differences were previously reported to significantly affect key clinical indicators such as operative bleeding volume and surgical operation time [22–24]. Herein, our findings showed a significant decrease in hemoglobin levels postoperatively in both groups, indicating notable bleeding due to the complex and lengthy nature of aortic dissection

surgery with cardiopulmonary bypass. Based on our clinical experience, we have learned that administering treatments to stabilize coagulation before infusing residual physical blood after cardiopulmonary bypass cessation could indeed effectively improve postoperative coagulation function, offering important clinical benefits to the patients.

The present study reveals that before surgery, there were no statistically significant differences between the two groups in terms of hemoglobin levels and various indicators of coagulation. However, after surgery, significant improvements were observed, with superior outcomes seen in the research group, which were significantly better compared to the control group ($p < 0.05$). Additionally, patients in the research group required significantly fewer blood products, experienced reduced amounts of bleeding and total body fluid inflow and outflow, and had markedly shorter durations of hemostasis, surgery and anesthesia compared to those in the control group ($p < 0.05$).

Consistent with previous studies [25–27], our findings comprehensively demonstrate the numerous advantages of delayed infusion of residual physical blood, including improved coagulation function, reduced bleeding volume, and shortened duration of surgery. Further analysis suggests that delayed infusion of residual physical blood effectively minimized interference and promoted coagulation function improvement compared to

immediate infusion. Thus, intraoperative bleeding was significantly reduced, and hemostasis time was effectively managed in the patients. Moreover, due to the decreased bleeding volume, we observed a notable reduction in the utilization of related blood products during surgery, consistent with previous reports [28–30].

This study has several limitations that warrant consideration. As a retrospective study, we had no control over the methods or quality of data collection, which might have introduced potential biases, including inconsistencies in data, absence of certain critical variables, or measurement errors. In future research focusing on the optimal timing of residual physical blood infusion, further comparisons could explore the effects of different time points, such as the moment of cardiopulmonary bypass shutdown or intervals ranging from 0.5 to 2 hours post-shutdown, on patients' coagulation function during aortic dissection surgery with cardiopulmonary bypass. These comparisons could offer a scientific and accurate reference basis for clinical practice [31–34].

5. Conclusions

In summary, this study showed that adjusting coagulation function followed by delayed infusion of residual physical blood could effectively enhance coagulation function, decrease bleeding volume and total body fluid exchange, and shorten hemostasis time in patients undergoing aortic dissection surgery under cardiopulmonary bypass.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analyzed during this study are included in this published article.

AUTHOR CONTRIBUTIONS

XYLi—Performed material preparation and the experiments. HZ, XYLu and LZ—Performed data collection and analysis. JJG and JZ—Written the first draft of the manuscript. All authors commented on previous versions of the manuscript. All authors contributed to the study conception and design. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All procedures performed in studies involving human participants were in accordance with the standards upheld by the Ethics Committee of the Taihe Hospital Affiliated Hospital of Hubei University of Medicine and with those of the 1964 Helsinki Declaration and its later amendments for ethical research involving human subjects (Approval No. 2019-013). Written informed consent was obtained from a legally authorized representative for anonymized patient information to be published in this article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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