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ORIGINAL ARTICLE

Effect of Point-of-care Hemoglobin/Hematocrit Devices and Autologous Blood Salvage on Reduction of Perioperative Allogeneic Blood Transfusion

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Objective To evaluate the effect of point-of-care hemoglobin/hematocrit (POC HGB/HCT) devices and intraoperative blood salvage on the amount of perioperative allogeneic blood transfusion and blood conservation in clinical practice.

Methods A total of 46 378 medical records of 22 selected hospitals were reviewed. The volume of allogeneic red blood cell and plasma, number of patients transfused, number of intraoperative autologous blood salvage, total volume of autologous blood transfusion, and amount of surgery in the year of 2011 and 2013 were tracked. Paired *t*-test was used in intra-group comparison, while *t*-test of two isolated samples carried out in inter-group comparison. $P < 0.05$ was defined as statistically significant difference.

Results In the hospitals where POC HGB/HCT device was used ($n=9$), the average allogeneic blood transfusion volume per 100 surgical cases in 2013 was significantly lower than that in 2011 (39.86 ± 20.20 vs. 30.49 ± 17.50 Units, $t=3.522$, $P=0.008$). In the hospitals without POC HGB/HCT meter, the index was not significantly different between 2013 and 2011. The average allogeneic blood transfusion volume was significantly reduced in 2013 than in 2011 in the hospitals where intraoperative autologous blood salvage ratio [autologous transfusion volume/(autologous transfusion volume+allogeneic transfusion volume)] was increased ($n=12$, $t=2.290$, $P=0.042$). No significant difference of the above index was found in the hospitals whose autologous transfusion ratio did not grow.

Conclusion Intraoperative usage of POC HGB/HCT devices and increasing autologous transfusion ratio could reduce perioperative allogeneic blood transfusion.

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PATIENTS who received allogeneic blood transfusion may have a potential risk of transfusion transmitted infectious disease. In addition, transfusion related immunomodulation also increases the risk of postoperative infection¹ and tumor recurrence.² Therefore, it is encouraged to minimize or avoid allogeneic transfusion with the premise of patient's safety. According to published data, 60% of allogeneic blood was transfused to surgical patients.³ Perioperative blood management plays very important roles in the reduction of allogeneic transfusion and the improvement of patients' outcome.

Transfusion guidelines^{4, 5} also suggest intraoperative point-of-care hemoglobin/hematocrit (POC HGB/HCT) test. Decision of red blood cell transfusion should be based on the result, medical history, and clinical demonstration. The conventional routine hematologic test by hospital central lab is not practical to be used intraoperatively because of the long turnaround time. Value of hemoglobin can be obtained quicker by the blood gas device which has been installed in the operating room in quite a few hospitals. But the application of blood gas was limited by several factors such as minimum of 0.5 ml venous or arterial blood, access site covered by surgical sheet, the invasive process and relevantly high expense. The POC HGB/HCT test which only needs 1 drop of capillary blood is quicker and cheaper. It is coming to be the best option for perioperative HGB/HCT measurement. This kind of device was getting more popular recently in operating rooms but its efficacy in reduction of erythrocyte consumption by guiding transfusions has not been reported.

Many studies showed that intraoperative autologous salvage blood transfusion was helpful in reduction of perioperative allogeneic transfusion rate and transfusion volume.⁶ Auto-transfusion devices were installed in more and more hospitals and whether or not supplied with this device was also set as one of the evaluation indexes by some local healthcare administrative department.⁷ However, further evaluation of these indexes is necessary as to properly reflecting blood conservation work of the hospitals.

The goal of this study was to evaluate whether or not intraoperative POC HGB/HCT test and autologous blood salvage device can reduce allogeneic blood transfusion and provide the reference for blood conservation for the administrative department developing appropriate evaluation indexes.

PATIENTS AND METHODS

Patients

Using a random sampling with a sampling proportion of

10% in the year of 2011 and 2013 respectively, 46 378 records of 22 selected hospitals, including Daqing Oilfield General Hospital, the Affiliated Hospital of Hainan Medical University, Haikou People's Hospital, Huashan Hospital, Shanghai General Hospital, Siping Central People's Hospital, Changchun Central Hospital, Yueyang Second People's Hospital, Guizhou Sinan People's Hospital, Zunyi Maternal and Child Health Hospital, Jingdezhen Second People's Hospital, the First Affiliated Hospital of Nanchang University, Jiangxi Provincial People's Hospital, Weifang People's Hospital, Hunan Provincial People's Hospital, Shanghai Children's Medical Center, Qingdao Municipal Hospital, the Third Xiangya Hospital of Central South University, the First People's Hospital of Yueyang, the Affiliated Hospital of Qingdao University, the Affiliated Hospital of Guizhou Medical University, and Guizhou Provincial People's Hospital, were reviewed through exploring database and original records. The volume of allogeneic red blood cell and plasma, number of patients transfused, number of intraoperative autologous blood salvage, total volume of autologous blood transfusion and amount of surgery in each year were recorded.

Statistical analysis

Data analysis was performed by SPSS 17.0 software (Microsoft Corporation). All data were expressed as mean±standard deviation (SD). Paired *t*-test was used in intra-group comparison, while *t*-test of two isolated samples was performed in inter-group comparison. *P*<0.05 was defined as statistically significant difference.

RESULTS

Allogeneic blood transfusion in surgical patients

Twenty-two inspected hospitals were classified into two groups by whether or not the POC HGB/HCT device was used in operation by the end of 2013: non-using group (*n*=13) and using group (*n*=9). There was no significant difference in average allogeneic red blood cell volume, plasma volume, and number of surgical patients received allogeneic blood transfusion per 100 surgeries between the non-using and using POC HGB/HCT groups in 2011 and 2013, respectively (all *P*>0.05), Table 1.

There was no significant difference of average allogeneic red blood cell transfusion volume, plasma volume, and number of allogeneic transfused patients per 100 surgeries between 2013 and 2011 (all *P*>0.05) in the non-using group. On the contrary, the average allogeneic red blood cell transfusion volume per 100 surgeries was significantly lower in 2013 comparing with 2011 (*t*=3.522,

$P<0.05$) in the using group, while the plasma volume and number of allogeneic transfused patients per 100 surgeries were not significantly different during that period. (Table 1)

Relation of intraoperative autologous salvage blood transfusion and allogeneic transfusion

Autologous salvage blood transfusion was used in all the inspected hospitals both in 2011 and 2013. Hospitals were classified by whether or not the patient's number of autologous transfusion per 100 surgeries increased in 2013 than in 2011: the increased group ($n=16$) and non-increased group ($n=6$). The average allogeneic red blood cell transfusion volume, plasma volume, and number of allogeneic transfused patients per 100 surgeries in both 2013 and 2011 were not significantly different between the two groups ($P>0.05$). (Table 2)

In hospitals of the increased group, there were no significant difference of average allogeneic red blood cell transfusion volume, plasma volume, and number of allogeneic transfused patients per 100 surgeries between 2013 and 2011 (all $P>0.05$). In the non-increased group, the average allogeneic red blood cell transfusion volume per 100 surgeries was significantly reduced in 2013 than in 2011 ($t=12.792$, $P<0.05$), while plasma volume and number of allogeneic transfused patients per 100 surgeries were not significantly different (all $P>0.05$). (Table 2)

Hospitals were then classified into two groups by whether the volume of autologous transfusion per 100 surgeries increased in 2013 than in 2011 or not: the increased group ($n=13$) and non-increased group ($n=9$). The average allogeneic red blood cell transfusion volume, plasma volume, and number of allogeneic transfused

patients per 100 surgeries of both 2013 and 2011 were not significantly different between the two groups ($P>0.05$). (Table 3)

In the hospitals of the increased group, there was no significant difference of average allogeneic red blood cell transfusion volume, plasma volume, and number of allogeneic transfused patients per 100 surgeries between 2013 and 2011 (all $P>0.05$). In the non-increased group, the average allogeneic red blood cell transfusion volume per 100 surgeries was significantly reduced in 2013 than in 2011 ($t=4.234$, $P<0.05$), while plasma volume and number of allogeneic transfused patients per 100 surgeries were not significantly different ($P>0.05$). (Table 3)

Hospitals were classified into two groups by whether the ratio of autologous transfusion [autologous transfusion volume/(autologous+allogeneic transfusion volume)] per 100 surgeries was increased in 2013 than in 2011 or not: the increased group ($n=12$) and non-increased group ($n=10$). The average allogeneic red blood cell transfusion volume, plasma volume, and number of allogeneic transfused patients per 100 surgeries of both 2013 and 2011 were not significantly different between the two groups ($P>0.05$). (Table 4)

In the hospitals of the increased group, the average allogeneic red blood cell transfusion volume per 100 surgeries was significantly reduced in 2013 than in 2011 ($t=2.290$, $P=0.042$), while plasma volume and number of allogeneic transfused patients per 100 surgeries did not have significant difference (all $P>0.05$). In the non-increased group, there was no significant difference of average allogeneic red blood cell transfusion volume, plasma volume, and number of allogeneic transfused patients per 100 surgeries between 2013 and 2011 ($P>0.05$). (Table 4)

Table 1. Comparison of allogeneic blood transfusion in hospitals using and not using POC HGB/HCT devices in 2011 and 2013[§]

Groups	Number of hospitals	Items	2011	2013	P value
Non-using group	13	RBC (Units/100 surgeries)	31.79±21.74	29.77±20.91	0.421
		FFP (Units/100 surgeries)	32.16±28.49	29.30±30.50	0.250
		Number of patients transfused ($n/100$ surgeries)	14.01±12.19	13.09±13.42	0.342
Using group	9	RBC (Units/100 surgeries)	39.86±20.20	30.49±17.50	0.008
		FFP (Units/100 surgeries)	22.49±18.36	17.35±14.76	0.096
		Number of patients transfused ($n/100$ surgeries)	22.79±26.65	19.95±21.06	0.256

§: Plus-minus values are means±SD.

POT HGB/HCT: point-of-care hemoglobin/hematocrit; RBC: red blood cell; FFP: fresh frozen plasma.

Table 2. Comparison of allogeneic blood transfusion in hospitals with increased and non-increased number of patients with autologous blood transfusion in 2011 and 2013[§]

Groups	Number of hospitals	Items	2011	2013	P value
Non-increased group	6	RBC (Units/100 surgeries)	41.11±21.49	29.41±20.42	0
		FFP (Units/100 surgeries)	34.71±22.32	25.73±20.89	0.132
		Number of patients transfused (n/100 surgeries)	22.41±33.28	17.21±25.79	0.161
Increased group	16	RBC (Units/100 surgeries)	32.83±21.09	30.32±19.34	0.299
		FFP (Units/100 surgeries)	25.76±25.94	23.91±27.65	0.205
		Number of patients transfused (n/100 surgeries)	15.80±11.96	15.40±12.21	0.615

§: Plus-minus values are means±SD.

Table 3. Comparison of allogeneic blood transfusion in hospitals with increased and non-increased amount of autologous blood transfusion in 2011 and 2013[§]

Groups	Number of hospitals	Items	2011	2013	P value
Non-increased group	9	RBC (Units/100 surgeries)	31.89±22.59	23.72±18.97	0.003
		FFP (Units/100 surgeries)	25.59±22.64	19.46±19.25	0.123
		Number of patients transfused (n/100 surgeries)	16.94±27.75	13.40±21.43	0.147
Increased group	13	RBC (Units/100 surgeries)	37.31±20.50	34.46±18.72	0.341
		FFP (Units/100 surgeries)	30.01±26.97	27.83±29.34	0.221
		Number of patients transfused (n/100 surgeries)	18.06±11.93	17.62±13.51	0.653

§: Plus-minus values are means±SD.

Table 4. Comparison of allogeneic blood transfusion in hospitals with increased and non-increased ratio of autologous blood transfusion in 2011 and 2013[§]

Groups	n	Items	2011	2013	P value
Non-increased group	10	RBC (Units/100 surgeries)	29.73±22.27	24.76±18.06	0.141
		FFP (Units/100 surgeries)	24.61±22.07	19.50±18.16	0.166
		Number of patients transfused (n/100 surgeries)	16.15±26.31	12.84±20.29	0.130
Increased group	12	RBC (Units/100 surgeries)	39.56±19.75	31.33±19.64	0.042
		FFP (Units/100 surgeries)	31.20±27.49	28.50±30.53	0.134
		Number of patients transfused (n/100 surgeries)	18.81±12.08	18.44±13.75	0.729

§: Plus-minus values are means±SD.

DISCUSSION

To improve prognosis of patients by reducing complications associated with allogeneic blood transfusion, doctors and healthcare service institutes have tried to implement specific policies to minimize allogeneic blood transfusion. Meanwhile, many clinical researches were conducted to evaluate the efficacy of these policies.

Many clinical studies showed restricted transfusion strategy could reduce the allogeneic blood transfusion without compromising patient safety in cardiac surgeries.^{8,9} Restricted transfusion strategy means transfusion is only triggered by a relatively low level of HGB/HCT. The premise of the restricted strategy is HGB/HCT level has to be measured before the decision of transfusion. But it was not the case of many doctors' practice in the past. Their decision of transfusion was usually made based on their

own experience. One study which reviewed 6384 transfusion cases from 2006-2009 of 3 first level hospitals in China revealed that HGB/HCT was measured only in 1274 (19.96%) cases before transfusion.¹⁰

Moreover, quite a few transfusion guidance suggested monitoring perioperative HGB/HCT.^{4, 5} The accurate, quick, convenient, and cheap monitoring devices are necessary to enhance the compliance of the guidance. The turnaround time of conventional complete blood count test is too long. Meanwhile, blood gas test is not well accepted because of the higher price. Therefore, the accurate, quick and cheap POC HGB/HCT devices were introduced to many hospitals. Only one drop of capillary blood is needed for the test, which is very convenient during the surgery. Up to now, there has not been multi-center study evaluating the efficacy of using those devices in reduction of allogeneic blood transfusion. In the 22 inspected hospitals of current study, there were 9 hospitals using those devices while 13 hospitals not using them in 2011 and 2013. The average allogeneic blood transfusion volume per 100 surgeries in 2013 was significantly lower than that in 2011 in the hospitals using the device guiding transfusion. There was no difference between 2013 and 2011 in those hospitals without the device. It shows that using those HGB/HCT devices can reduce perioperative allogeneic blood transfusion.

Besides restricted transfusion strategy, another verified blood conservative method by clinical research is intraoperative autologous blood transfusion.⁶ Intraoperative autologous blood transfusion attracted more and more attention from doctors and administrative department recently. Whether or not equipped with the equipment was even set as one of the grading criteria of hospitals in China. The growth of number and volume of autologous transfusion were set as quality control indexes of blood management achievement. All 22 inspected hospitals in this study had intraoperative autologous blood transfusion equipment. In the comparison of blood usage of 2013 and 2011, the average allogeneic transfusion volume was not significantly lower in 2013 than that in 2011 in the hospitals whose autologous transfusion volume and number of cases increased. On the contrary, it was reduced in those hospitals without growth of number and volume of autologous blood transfusion. So it is inappropriate to evaluate the blood management work by the growth of number or volume of intraoperative autologous transfusion. Hospitals should not pursue to maximize the usage of the technology. Under some specific circumstances, allogeneic transfusion volume may drop together with autologous transfusion. The potential reasons of the results are: (1) In hospitals with growing number of cases and volume of autologous

transfusion, the growth of surgeries was mainly those with excessive blood loss which demands huge volume of transfusion. Even with autologous blood salvage the demand of allogeneic blood is still huge. (2) The ultimate target of blood conservation is the reduction of the allogeneic blood transfusion by combination of multi-discipline methods. Intraoperative autologous blood transfusion is one of them and only helpful in reducing allogeneic transfusion in the surgeries with large amount of blood loss. Simply pursuing to increase the usage and neglecting combination with other methods can be the reason why the autologous transfusion volume grows without reduction of allogeneic blood transfused. Restricted transfusion criteria, effective management of blood loss might reduce the transfusion demands and then reduce the allogeneic blood transfusion in those hospitals without growth of autologous transfusion.

Another index often used to evaluate blood management of hospitals is autologous transfusion ratio [autologous transfusion volume/(autologous transfusion volume+ allogeneic transfusion volume)]. Beijing Municipal Health Bureau⁷ requested that autologous transfusion ratio should reach more than 20% in the first level hospitals. There were 12 hospitals in the study whose autologous transfusion ratio was increased in 2013. Their average allogeneic blood transfusion volume per 100 surgeries was significantly lower than that in 2011. There was not the difference of it in the 10 hospitals whose autologous transfusion ratio did not grow. Growth of autologous transfusion ratio can result in allogeneic transfusion reduction. This index is appropriate to evaluate the blood management work.

In our study both POC HGB/HCT test and growth of autologous transfusion ratio can result in the reduction of average allogeneic transfusion volume per 100 surgeries but have no impact on the average number of allogeneic transfusion cases per 100 surgeries. POC HGB/HCT test can only provide the evidence in transfusion decision, while there are additional factors affecting the decision of transfusion such as the acceptance of restricted transfusion strategy, monitor of other important parameters presents or not, the sufficiency of allogeneic blood supply and the patient's attitude of allogeneic transfusion. Only applying POC HGB/HCT device is not enough to ensure allogeneic transfusion reduction. Furthermore, we found there was no difference between the groups for ratio, volume or number of autologous transfusion. So it could be inferred that implementing of POC HGB/HCT test might not influence the intraoperative autologous transfusion.

As reported, intraoperative autologous transfusion can

reduce allogeneic transfusion rate in orthopedic, cardiac, and trauma patients.⁶ Our analysis does not focus on a specific type of surgery but on the whole hospital. In general, only a few patients are suitable to use this technique and getting benefit from it. So it might be difficult to find reduction of allogeneic transfusion as a result of intraoperative autologous blood transfusion in some hospitals. In addition to the observation, plasma consumption did not drop with the usage of POC HGB/HCT device or growth of autologous transfusion in 2013. Therefore other measures should be applied to ensure the proper use of plasma, such as monitoring and protection of coagulation system.

The limitation of the study is that the effect of POC HGB/HCT and autologous blood salvage on allogeneic blood transfusion might not be the same concerning on different types of surgeries. And the distribution of surgery types could also be different among different hospitals. Therefore, future studies are needed to demonstrate which specific blood management technique could be more effective in certain type of surgery, which could offer a more straightforward indication for the clinical application of these techniques.

In summary, we concluded that using POC HGB/HCT intraoperative test or increasing autologous blood salvage ratio could reduce perioperative allogeneic blood transfusion volume, and these techniques might be encouraged in the clinical practice.

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