

Crossmatch to Transfusion Ratio of Blood and Risk factors Associated with Blood Transfusion in Patients Undergoing Elective Hepatic Resection: Retrospective Review

Cherdkiat Karnjanarachata*, Phisut Lavanrattanakul*, Worapot Apinyachon*, Thanist Pravitharangul*

*Department of Anesthesiology, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok 10400, Thailand

Background: Blood components are routinely prepared for hepatic resection surgery, however; with current surgical techniques, red blood cell transfusion rate is decreasing and unnecessary crossmatch procedure is also burden to the blood banks.

Objectives: To identify crossmatch to transfusion ratio (CT ratio) in the patients underwent hepatic resection.

Methods: Medical records of 322 patients who underwent hepatic resection in Ramathibodi hospital between January 2013 to December 2016 were retrospectively reviewed. The CT ratio was defined by the proportion of cross-matched unit of packed red cells (PRC) and transfused unit of PRC either intraoperative or 24 hours postoperative periods.

Results: Four units of PRC were prepared for the operation in 88.50% of the patients. However, as much as 57.45% of the patients did not receive any PRC transfusion.

The calculated CT ratio of hepatectomy was 3.36 for intraoperative and 24 hours postoperative transfusion. The independent risk factors for intraoperative and 24 hours postoperative transfusion are right lobectomy operation (OR 5.64, 95%CI 2.37–13.39), wedge hepatectomy more than or equal to 3 lesions (OR 2.73, 95%CI 1.19-6.30), preoperative hematocrit $\leq$ 34% (OR 4.13, 95%CI 1.82-9.42), and preoperative INR $\geq$ 1.1 (OR 2.79, 95%CI 1.56-4.98).

Conclusions: This study found that the CT ratio was 3.36. This high CT ratio means the prepared PRC for operation is much more than required. Right lobectomy, wedge hepatectomy more than 3 lesions, preoperative anemia, and coagulopathy were independent risk factors for blood transfusion in hepatic resection.

Keywords: blood transfusion, CT ratio, hepatic resection

วิทยุสื่อสาร 2562; 45(1): 1-6. • Thai J Anesthesiol 2019; 45(1): 1-6.

Introduction

Hepatectomy is one of the major abdominal surgery that had high blood loss in the past¹. After the improvement of surgical and anesthetic technique, blood loss is significantly reduced. While blood components are routinely prepared, only about 17 to 37% of patients who underwent elective hepatectomy received packed red cells (PRC) transfusion in perioperative periods²⁻⁴. Excessive preparation of PRC causes increase ward and blood bank work tasks, limits blood resource for other patients and increases unnecessary hospitalization cost⁵. The crossmatch to transfusion ratio (CT ratio) is used to evaluate the optimization of preparation and transfusion. In addition, CT ratio value of two or less means crossmatching of blood component is acceptable for safety and

economy reasons⁶. Up until now, there is no data of CT ratio for elective hepatectomy in Ramathibodi hospital or even in Thailand. So, the purpose of this study is to identify CT ratio in the patients who underwent elective hepatectomy in Ramathibodi hospital during intraoperative and 24 hours postoperative periods. Furthermore, risk factors associated with PRC transfusion were also identified.

Methods

Patient selection and data collection

The inclusion criteria for this study were all adult (age $\geq$ 18 years) who underwent hepatectomy in Ramathibodi hospital between January 2013 to December 2016. After received Ramathibodi clearance committee approval, the medical records were

Correspondence to: Cherdkiat Karnjanarachata M.D., Email: chird_na@yahoo.com

Received 24 June 2018, Revised 9 Nov 2018, Accepted 9 Nov 2018

retrospectively reviewed and the collected data were patient demographic profiles, blood components that ordered for preparation and transfusion, diagnosis and operation from operative note, laboratory values, and estimated blood loss. For demographic data, age, sex, body weight, height, comorbidity (e.g. smoking, alcoholism, hypertension, diabetes mellitus, dyslipidemia, and cirrhosis), ASA physical status, history of previous abdominal surgery, and history of antiplatelet and anticoagulant were collected. CT ratio of blood components was calculated by overall units of each kind of blood components preparation divided by overall transfused units of that kind of components in intraoperative and 24 hours postoperative period.

Statistical analysis

The statistical data were presented by median (interquartile range) or mean $\pm$ standard deviation as appropriate. For continuous variables, Student's *t*-test, or Mann-Whitney U test are used. Categorical data are analyzed with Pearson χ^2 test. The risk factor for PRC transfusion were analyzed with univariate and multivariate logistic regression model. All data were analyzed with SPSS version 20.0. P value greater than 0.05 is considered statistically significant.

Results

After screening, 356 medical records were matching with inclusion criteria. Thirty-four patients were excluded due to loss of medical record (5 records), incomplete perioperative record (16 records), emergency liver resection (2 records), and liver transplantation (11 records). Total 322 patients were enrolled for analysis. Patient demographics data are present in table 1. One hundred and ninety-three patients (59.94%) were male. Average age was 54.62 ± 13.86 years old. Mainly diagnoses were hepatocellular carcinoma with 129 cases (40.06%) and liver metastasis with 75 cases (23.29%). Eighty-three cases (25.78%) of wedge resection less than 3 lesions were the majority of operation. About co-morbidity, seventy-four cases (22.98%) had cirrhosis and 165 cases (51.24%) had history of previous abdominal surgery. The median value of preoperative hematocrit was 39.90 (36.80, 42.40) percent, platelet count was 237,000 (179,000, 289,000) mm^3 , and INR was 1.02 (0.98, 1.08). Estimated blood loss was around 700 (400, 1300) mL.

Table 1 Patient demographic data

Variables		Statistics
Gender	Male	193 (59.94%)
	Female	129 (40.06%)
Age (years)		54.62 ± 13.86
Body weight (kg)		62.64 ± 12.66
Height (cm)		161.59 ± 8.41
BMI (kg/m^2)		23.89 ± 3.95
ASA physical status	I	38 (11.8%)
	II	120 (37.27%)
	III	156 (48.45%)
	IV	8 (2.48%)
Diagnosis	Hepatocellular carcinoma	132 (40.99%)
	Liver metastasis tumor	72 (22.36%)
	Cholangiocarcinoma	48 (14.91%)
	Liver donor	43 (13.35%)
	Other	27 (8.38%)
Comorbid (s)	Previous abdominal surgery	165 (51.24%)
	Hypertension	129 (40.06%)
	Smoking	116 (36.02%)
	Alcohol	110 (34.16%)
	Cirrhosis	74 (22.98%)
	Hepatitis B infection	73 (22.67%)
	Diabetes mellitus	66 (20.5%)
	Dyslipidemia	66 (20.5%)
	Previous chemotherapy	61 (18.94%)
	Hepatitis C infection	27 (8.39%)
	Previous antiplatelet use	25 (7.76%)
	Chronic kidney disease	12 (3.73%)
	Cerebrovascular disease	9 (2.8%)
	Coronary artery disease	5 (1.55%)
	Previous anticoagulant use	3 (0.93%)
Multi-comorbidities		241 (74.84%)
NYHA Functional class	I	283 (87.89%)
	II	36 (11.18%)
	III	3 (0.93%)
Laboratory	Hemoglobin (Hb, g/dL)	13.10 (12.00, 14.10)
	Hematocrit (Hct, %)	39.90 (36.80, 42.40)
	Platelet ($/\text{mm}^3$)	237000 (179000, 289000)
	INR (mg/dL)	1.02 (0.9, 1.08)
	Blood urea nitrogen (BUN, mg/dL)	12.00 (10.00, 15.00)
	Creatinine (Cr, mg/dL)	0.83 (0.68, 0.98)
	AST (U/L)	32.00 (23.00, 50.00)
	ALT (U/L)	37.00 (28.00, 56.00)
	Estimated Blood Loss (mL)	700 (400, 1300)

Data is represented as number (%), mean $\pm$ standard deviation, median (interquartile range)

BMI-Body mass index, ASA physical status-The American Society of Anesthesiologists physical status, NYHA-New York Heart Association, INR-International Normalized Ratio, AST-Aspartate amino transferase, ALT-Alanine amino transferase

Total number of PRC preparation preoperatively were 1,328 units. Two hundred eighty-five patients (88.5%) were prepared with 4 units of PRC and 23 (7.1%) patients were prepared with PRC more than 4 units. All PRC units were prepared with crossmatching method. Unit of PRC received by the patient was presented in table 2. Most of the patients did not receive any unit of PRC, accounted for 65.84% in intraoperative periods and 57.45% in intraoperative and 24 hours postoperative periods. Whereas, the number of patients who required more than 4 units of PRC were as few as 11 (3.42%) cases in intraoperative periods and 20 (6.21%) cases in intraoperative and 24 hours postoperative periods. Two hundred and ninety-one units of PRC were transfused to 110 patients in intraoperative period and 104 units of PRC were transfused to 63 patients in 24 hours postoperative periods. Total 395 units of PRC were transfused leading to calculated CT ratio = 3.36. CT ratio of fresh frozen

plasma was 3.91 and CT ratio of platelet concentrate was 22.48 as shown in table 3.

Table 2 Unit of PRC received by the patients

	No. of PRC Received	No. of patient (%)
Intraoperative periods	0	212 (65.84%)
	1	38 (11.80%)
	2	33 (10.25%)
	3	18 (5.59%)
	4	10 (3.10%)
	>4	11 (3.42%)
Intraoperative and the first 24 hours postoperatively	0	185 (57.45%)
	1	54 (16.77%)
	2	32 (9.94%)
	3	22 (6.83%)
	4	9 (2.80%)
	>4	20 (6.21%)
PRC-Packed red blood cells		

Table 3 CT ratio of blood component

	Preoperative preparation		Intraoperative utilization		Postoperative utilization		CT Ratio†
	Pt with crossmatch (n)	Total crossmatched (Units)	Pt received transfusion (n)	Total transfused (Units)	Pt received transfusion (n)	Total transfused (Units)	
PRC	322	1,328	110	291	63	104	3.36
FFP	319	1,362	52	147	68	201	3.91
LPPC	304	2,338	11	55	13	49	22.48

PRC-Packed red blood cell, FFP-Fresh frozen plasma, LPPC-Leukocyte poor platelet concentrate, Pt-Patient

†CT Ratio = Preoperative / (Intraoperative + Postoperative) of units of each blood components

From univariate analysis of forty-six factors totally, ten variables were identified to be predictors of perioperative PRC transfusion in intraoperative and 24 hours postoperative periods as shown in table 4. All factors with P value less than 0.05 will be analyzed again with multivariate logistic regression (table 5), four factors that remained significant independent risk factors for

PRC transfusion in intraoperative and 24 hours postoperative periods were right lobectomy operation (OR 5.64, 95%CI 2.37-13.39), wedge hepatectomy more than or equal to 3 lesions (OR 2.73, 95%CI 1.19-6.30), preoperative hematocrit $\leq$ 34% (OR 4.14, 95%CI 1.81-9.42), and preoperative INR $\geq$ 1.1 (OR 2.79, 95%CI 1.56-4.98).

Table 4 Univariate analysis of intraoperative and 24 hours postoperative PRC transfusion

	Transfused (N=137)	Not transfused (N=185)	Odds ratio (95% CI)	P value
Male	80 (58.39%)	113 (61.08%)	0.89 (0.57-1.40)	0.63
Body weight (kg)	62.8 ± 13.27	62.53 ± 12.22	1.00 (0.98-1.02)	0.85
Height (cm)	161.21 ± 8.68	161.88 ± 8.22	0.99 (0.97-1.02)	0.48
ASA physical status class 3-4	78 (56.93%)	86 (46.49%)	1.52 (0.98-2.37)	0.06
Diagnosis				
Hepatocellular carcinoma	52 (37.96%)	77 (41.62%)	0.86 (0.55-1.35)	0.51
Cholangiocarcinoma	32 (23.36%)	16 (8.65%)	3.22 (1.68-6.15)	<0.001 [*]
Liver metastasis	33 (24.09%)	42 (22.7%)	1.08 (0.64-1.82)	0.77
Liver donor	8 (5.84%)	35 (18.92%)	0.27 (0.12-0.59)	0.001 [*]
Liver hemangioma	3 (2.19%)	2 (1.08%)	2.05 (0.34-12.43)	0.44
Gall bladder carcinoma	2 (1.46%)	4 (2.16%)	0.67 (0.12-3.71)	0.65
Others	7 (5.11%)	8 (4.32%)	1.19 (0.42-3.37)	0.74
Operation				
Right lobectomy	23 (16.79%)	8 (4.32%)	4.46 (1.93-10.32)	<0.001 [*]
Left lobectomy	3 (2.19%)	5 (2.7%)	0.81 (0.19-3.43)	0.77
Left lateral lobectomy	10 (7.3%)	41 (22.16%)	0.28 (0.13-0.58)	0.001 [*]
Segmentectomy < 3 segment	10 (7.3%)	29 (15.68%)	0.42 (0.20-0.90)	0.03 [*]
Segmentectomy ≥ 3 segment	5 (3.65%)	3 (1.62%)	2.30 (0.54-9.79)	0.26
Wedge resection < 3 lesions	29 (21.17%)	54 (29.19%)	0.65 (0.39-1.09)	0.11
Wedge resection ≥ 3 lesions	17 (12.41%)	11 (5.95%)	2.24 (1.01-4.95)	0.04 [*]
Hilar resection	16 (11.68%)	4 (2.16%)	5.98 (1.95-18.33)	0.002 [*]
Nonspecific hepatectomy	15 (10.95%)	17 (9.19%)	1.22 (0.58-2.53)	0.60
Extended right hepatectomy	3 (2.19%)	0 (0%)	9.65 (0.49-188.47)	0.13
Extended left hepatectomy	2 (1.46%)	3 (1.62%)	0.90 (0.15-5.45)	0.91
Lap hand-assisted left hepatectomy	0 (0%)	7 (3.78%)	0.08 (0.01-1.44)	0.09
Other operation	4 (2.92%)	4 (2.16%)	1.29 (0.32-5.24)	0.73
Comorbidities				
Cirrhosis	29 (21.17%)	45 (24.32%)	0.84 (0.49-1.42)	0.51
Hepatitis B virus infection	29 (21.17%)	44 (23.78%)	0.86 (0.51-1.46)	0.58
Hepatitis C virus infection	7 (5.11%)	20 (10.81%)	0.44 (0.18-1.08)	0.07
Diabetes mellitus	33 (24.09%)	33 (17.84%)	1.46 (0.85-2.52)	0.17
Hypertension	64 (46.72%)	65 (35.14%)	1.62 (1.03-2.54)	0.04 [*]
Chronic kidney disease	8 (5.84%)	4 (2.16%)	2.81 (0.83-9.52)	0.10
Dyslipidemia	31 (22.63%)	35 (18.92%)	1.25 (0.73-2.16)	0.42
Post chemotherapy	25 (18.25%)	36 (19.46%)	0.92 (0.53-1.63)	0.78
Previous abdominal surgery	65 (47.45%)	100 (54.05%)	0.77 (0.49-1.20)	0.24
On antiplatelet	12 (8.76%)	13 (7.03%)	1.27 (0.56-2.88)	0.57
On anticoagulant	2 (1.46%)	1 (0.54%)	2.73 (0.25-30.37)	0.42
Smoking	51 (37.23%)	65 (35.14%)	1.10 (0.69-1.73)	0.70
Alcoholism	45 (32.85%)	65 (35.14%)	0.90 (0.57-1.44)	0.67
Multiple comorbidities	102 (74.45%)	139 (75.14%)	0.96 (0.58-1.60)	0.89
NYHA Functional class II and III	18 (13.14%)	21 (11.35%)	1.18 (0.60-2.31)	0.63
Hct ≤ 34%	27 (19.7%)	9 (4.86%)	4.80 (2.18-10.59)	<0.001 [*]
Plt ≤ 100,000 /mm ³	2 (1.46%)	1 (0.54%)	2.73 (0.24-30.37)	0.41
INR ≥ 1.1	44 (32.12%)	26 (14.05%)	20.95 (2.18-201.24)	0.01 [*]
BUN ≥ 23 mg/dL	4 (2.92%)	9 (4.86%)	1.01 (0.97-1.06)	0.58
Cr ≥ 1.3 mg/dL	6 (4.38%)	8 (4.32%)	1.11 (0.62-1.97)	0.73
AST ≥ 50 U/L	44 (32.12%)	27 (20.00%)	1.01 (1.01-1.02)	0.01 [*]
ALT ≥ 50 U/L	49 (35.77%)	50 (27.03%)	1.00 (0.99-1.01)	0.21

Data is represented as number (%), mean±standard deviation

^{*}P value < 0.05

ASA physical status-The American Society of Anesthesiologists physical status, NYHA-New York Heart Association, Hct-Hematocrit, Plt-Platelet, INR-International Normalized Ratio, BUN-Blood urea nitrogen, Cr-Creatinine, AST-Aspartate amino transferase, ALT-Alanine amino transferase, Lap-Laparoscopic

Table 5 Multivariate analysis of intraoperative and 24 hours postoperative PRC transfusion

Risk factor	N (%)	Odds ratio	95% CI	P value
Hct $\leq$ 34 %	27 (19.7%)	4.13	1.82-9.42	0.001
INR $\geq$ 1.1	44 (32.12%)	2.79	1.56-4.98	0.001
Wedge resection $\geq$ 3 lesions	17 (12.41%)	2.73	1.19-6.30	0.018
Right lobectomy	23 (16.79%)	5.64	2.37-13.39	<0.001

*P value < 0.05

Hct-Hematocrit, Plt-Platelet, INR-International Normalized Ratio,

Discussion

From this study, we found that transfusion rate of elective hepatectomy in Ramathibodi hospital was 34.16% for intraoperative period and 42.55% for 24 hours perioperative period which was similar to previous studies²⁻⁴. The calculated CT ratio of elective hepatectomy found in our study was 3.36. Although, in 1976 Friedman BA *et al*, recommended the CT ratio of PRC transfusion should be less than or equal to 2, this recommendation used in general surgical operation that might be associated with less bleeding than hepatic resection⁷. The previous study performed by Johns Hopkins hospital found that CT ratio was 2.17 for elective hepatectomy², this value seemed quite lower than that found in our study. As the result, they adopt maximal surgical blood order schedule (MSBOS) program to guide PRC usage leading to efficiently reduction of excess blood component preparation⁸. In contrast, our institute routinely prepared four units of PRC for most of the case and did not have guideline to evaluate risk factors of PRC transfusion in patients who undergo hepatectomy. Moreover, mean estimated blood loss in our study was 700 mL whereas the previous study was only 450 mL². Even we had higher blood loss, our CT ratio was still higher than prior study. It emphasized that our institute excessively prepared blood component.

As we have already known that anemia was a risk factor associated with PRC transfusion. Small volume of blood loss may trigger PRC transfusion because it reaches transfusion threshold faster in patient with low hemoglobin level. We found preoperative hematocrit less than or equal to 34% was about four folds increased in risk for PRC transfusion. This value is quite similar to

previous studies^{3, 4} which found that preoperative hemoglobin concentration less than 12.5 g/dL was the predictor for perioperative blood transfusion in liver surgery. In addition, Donald J. Lucas *et al*, study found preoperative hematocrit below 36% was a risk factor for PRC transfusion in hepatopancreatobiliary surgery⁹. Another risk factors for transfusion shown in this study are coagulopathy and bleeding disorder. Similar to our study, INR $\geq$ 1.1 was found to be risk factor for transfusion.

We also found right lobectomy and wedge resection $\geq$ 3 lesions were the risk factors for PRC transfusion. Some type of hepatic resection was associated with more blood loss than the other due to extension of lesion, duration of surgery, and involvement of vessel near lesion. C. Pulitano *et al*, found the operation that need for exposure of vena cava was associated with blood transfusion⁴. Besides, Andrew J. Cockbain *et al*, found the risk was an extended resection (more than 5 segments). Moreover, some authors found that large tumor size (more than 3.5 cm), redo resection, and cirrhosis were shown as blood transfusion risk factors^{3,4}. However, cirrhosis and redo resection have not appeared to be significant risk factors in this study after multivariate analysis.

There were several limitations in this study. First, this study is single center retrospective study, so extrapolation of the results to another hospital may seems unsuitable. However, the risk factors associated with PRC transfusion we found are in the same way with other previous studies. They can at least be used as the warning factors for whom practice with this kind of patients. Second, some data such as tumor size and

location were not collected in this study which might be another risk factor associated with PRC transfusion. Third limitation was the periods of this study. Because the data was collected from the patient before low central venous pressure technique is generally applied which may influence blood transfusion. Lastly, those 10% data loss was quite a large number of patients and may alter the results of the study.

In conclusions, the CT ratio of 3.36 for elective hepatectomy patients in Ramathibodi hospital, means we may excessively crossmatch PRC. Hematocrit $\leq 34\%$, INR ≥ 1.1 , wedge resection ≥ 3 lesions, and right lobectomy are independent risk factors for PRC transfused in intraoperative and the first twenty four hours of the postoperative periods.

References

1. Carabini LM, Ramsey G. Hemostasis and Transfusion Medicine. In: Barash P, editor. Clinical Anesthesia. 7th ed. Philadelphia, PA: Wolters Kluwer Health; 2013.p.408-44.
2. Ejaz A, Frank SM, Spolverato G, Mavros M, Kim Y, Pawlik TM. Variation in the use of type and crossmatch blood ordering among patients undergoing hepatic and pancreatic resections. Surgery 2016;159:908-18.
3. Cockbain AJ, Masudi T, Lodge JP, Toogood GJ, Prasad KR. Predictors of blood transfusion requirement in elective liver resection. HPB (Oxford) 2010;12:50-5.
4. Pulitanò C, Arru M, Bellio L, Rossini S, Ferla G, Aldrighetti L. A risk score for predicting perioperative blood transfusion in liver surgery. Br J Surg 2007;94:860-5.
5. Subramanian A, Rangarajan K, Kumar S, Sharma V, Farooque K, Misra MC. Reviewing the blood ordering schedule for elective orthopedic surgeries at a level one trauma care center. J Emerg Trauma Shock 2010;3:225-30.
6. Friedman BA. An analysis of surgical blood use in United States hospitals with application to the maximum surgical blood order schedule. Transfusion 1979;19(3):268-78.
7. Friedman BA, Oberman HA, Chadwick AR, Kingdon KI. The maximum surgical blood order schedule and surgical blood use in the United States. Transfusion 1976;16:380-7.
8. Palmer T, Wahr JA, O'Reilly M, Greenfield ML. Reducing unnecessary cross-matching: a patient-specific blood ordering system is more accurate in predicting who will receive a blood transfusion than the maximum blood ordering system. Anesth Analg 2003;96:369-75.
9. Lucas DJ, Schexneider KI, Weiss M, et al. Trends and risk factors for transfusion in hepatopancreatobiliary surgery. J Gastrointest Surg 2014;18:719-28.