

The Effect of Preoperative Anemia on Postoperative Morbidity and Mortality in Patients Undergoing Thoracic Surgery[§]

Torasik Cerrahi Geçiren Hastalarda Preoperatif Aneminin Postoperatif Morbidite ve Mortaliteye Etkisi

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ABSTRACT

Objective: Anemia is common in patients undergoing thoracic surgery due to three main risk factors including iron deficiency, chronic disease and iatrogenic factors, all of which can be prevented and treated. Our hypothesis was that the incidence of anemia may be higher than expected and associated with perioperative complications.

Method: The data belonging to a total of 107 adult patients were included in the final analysis. We recorded demographic features, pre- and postoperative laboratory findings, comorbidities, blood transfusion rates, complications, mortality, type of surgery, rate of re-exploration, and duration of hospital stay.

Results: The incidence of anemia was 43.9%, being higher in men with 57.4 percent. Anemic patients had a significantly prolonged hospital stay, higher rate of ICU hospitalizations, higher levels of pre- and postoperative creatinine and lower levels of postoperative Hb, Htc and preoperative INR ($p < 0.05$).

Conclusion: Even though the rate of mortality was not affected, anemia was associated with a higher rate of ICU admission and longer hospital stay. In order to reduce anemia-induced perioperative complications, the treatment of preoperative anemia should be considered for thoracic surgery patients.

Keywords: anemia, morbidity, mortality, thoracic surgery

ÖZ

Amaç: Anemi, göğüs cerrahisi geçiren hastalarda demir eksikliği, kronik hastalık ve iatrojenik olmak üzere üç ana risk faktörü nedeniyle sık görülmektedir ve bunların tümü önlenemez ve tedavi edilebilir. Hipotezimiz anemi insidansının beklenenden yüksek olabileceği ve perioperatif komplikasyonlarla ilişkili olabileceği yönündeydi.

Yöntem: Toplam 107 yetişkin hastaya ait veriler nihai analize dâhil edildi. Demografik özellikler, ameliyat öncesi ve sonrası laboratuvar bulguları, komorbiditeler, kan transfüzyon oranları, komplikasyonlar, mortalite, cerrahi türü, re-eksplorasyon oranı, hastanede kalış süresi kaydedildi.

Bulgular: Anemi sıklığı % 43.9 iken, erkeklerde % 57.4 ile daha yüksekti. Anemik hastaların hastanede kalış süreleri anlamlı derecede uzun, YBÜ'ye yatış oranları daha yüksek, ameliyat öncesi ve sonrası kreatinin düzeyleri daha yüksek ve ameliyat sonrası Hb, Htc ve ameliyat öncesi INR düzeyleri daha düşüktü ($p < 0.05$).

Sonuç: Ölüm oranı etkilenmese de, anemi daha yüksek YBÜ'ye yatış oranı ve daha uzun hastanede kalış ile ilişkiliydi. Anemiye bağlı perioperatif komplikasyonları azaltmak için göğüs cerrahisi hastalarında preoperatif aneminin tedavi edilmesi düşünülmelidir.

Anahtar kelimeler: anemi, morbidite, mortalite, torasik cerrahi

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INTRODUCTION

Anemia is the most common hematological problem encountered in the preoperative period prior to a major elective surgery. The incidence of preoperative anemia ranges from 5% to 75% in surgical procedures ^[1]. There is limited data on the incidence of preoperative anemia in patients undergoing thoracic surgery. Chamogeorgakis et al. ^[2] analysed the data of 214 early stage non- small cell cancer patients undergoing surgery. They revealed in their study that the incidence of preoperative anemia was 28% in male and 8% in female patients. In another study, anemia was determined in 33% of patients with non-small cell lung cancer ^[3]. According to European Cancer Anemia survey, the incidence of anemia in patients with lung cancer was 37.6 percent ^[4].

Although preoperative anemia is a serious problem increasing the risk for preoperative RBC transfusion, morbidity, and mortality, it may not be of primary concerns of surgeons ^[5]. It has been known since long time that preoperative anemia increases the risk for postoperative complications, extends the length of hospital stay, and is associated with death. Nevertheless, often surgical teams generally do not take preoperative anemia into account as a risk factor and do not take sufficient necessary steps to correct the problem ^[6]. A study analyzing the risk factors associated with postoperative mortality and morbidity in a patient undergoing lung cancer resection demonstrated that preoperative anemia is closely associated with mortality ^[7]. Inflammation and anemia are common findings and independent prognostic factors in patients with lung cancer ^[8]. In a study including a total of 124 patients undergoing surgery for small cell lung cancer, it was reported that preoperative anemia had a significant effect on survival and lung cancer-specific mortality ^[2].

The hypothesis of this retrospective study is that the incidence of anemia may be higher than expected. Therefore, our primary aim was to analyze the incidence of preoperative anemia along with the associ-

ated postoperative complications. The secondary aim was to determine the consequences of anemia in patients undergoing thoracic surgery.

MATERIALS and METHODS

Ethical approval for this study (Ethical Committee No:09.2018.137) was obtained from the Ethical Committee of our University Hospital on 02.02.2018. We retrospectively analyzed the data belonging to a total of 110 adult patients undergoing thoracotomy or thoracoscopy between January, 2016 and July 2017. In case that a patient had multiple surgeries, only the data of the first surgery was taken into consideration. Patients, who had urgent surgery; aged below 18 years; with a known bleeding disorder; and those with renal insufficiency, hepatic insufficiency, or congestive heart failure were excluded from the study.

We recorded demographic features including age, gender, body mass index and ASA scores, preoperative laboratory blood test results including hemoglobin level, INR, creatinine and platelet counts, comorbidities, blood and blood product transfusions, complications, mortality, type of surgery, rate of re-exploration, length of Intensive Care Unit (ICU) and length of hospital stay. Patients were classified into two groups according to the presence or absence of preoperative anemia. The anemia was defined according to the World Health Organization (WHO) criteria as a hemoglobin level <12 g/dL in women and <13,0 g/dL in men ^[9]. Besides the patients were divided into two groups according to their requirement of treatment in ICUs and hospital wards. The demographics, types and duration of surgery, duration of hospital stay, perioperative laboratory values, the amount of bleeding, the consumption of blood products and complications were compared among ICU and non-ICU patients. The duration of surgery, amount of RBC transfusion, length of hospital stay, preoperative Hb and Htc values were also compared according to univariable and multivariable models using 95% confidence limits.

Statistical Analysis

The SPSS 22.0 program was used for the analysis of the study data. The descriptive statistics employed in the study were mean, standard deviation, median, minimum, maximum, frequency, and ratio. The Kolmogorov-Smirnov test was used to measure the distribution of variables. The Mann-Whitney U test was used to analyze quantitative independent data while the chi-square test was used to assess the qualitative independent data. In cases where the chi-square test conditions were not met, the Fisher test was used for the qualitative data. A value of $p < 0.05$ was considered statistically significant.

RESULTS

The thoracic operations performed for our patients were decortication, lobectomy, pneumonectomy, and sleeve lobectomy (Table 1). Three patients were excluded from the study because of missing data and ultimately the data on a total of 107 patients were analyzed within the scope of the study. The mean incidence of anemia was 43.9% among women, being higher in men with a rate of 57.4 percent. The groups with and without anemia did not significantly differ by age, gender distribution, BMI, ASA class distribution the length of surgery, and ICU stay, preoperative platelet transfusion rate, and perioperative

Table 1. Comparison of patient demographics, type of surgery, the duration of hospital and ICU stay, parameters for perioperative hematologic evaluation, the requirement for blood products and postoperative complications between patients with and without anemia.

	Anemia (-)		Anemia (+)		p	m
	Mean±sd/n (%)	Median	Mean±sd/n (%)	Median		
Age (years)	61.37±12.20	62.50	60.89±13.79	62.00	0.967	X ²
Gender					0.800	m
Female	27 (45.0%)		20 (42.6%)			
Male	33 (55.0%)		27 (57.4%)			
BMI	26.19±4.11	26.10	25.11±5.03	25.80	0.855	m
ASA	2.87±1.14	3.00	2.91±1.14	3.00	0.805	
Type of surgery					0.591	X ²
Decortication	7 (11.7%)		3 (6.4%)			
Lobectomy	46 (76.7%)		36 (76.6%)			
Pneumonectomy	3 (5.0%)		5 (10.6%)			
Sleeve resection	4 (6.7%)		3 (6.4%)			
Duration of surgery (h)	4.14±1.43	4.00	4.07±1.57	4.00	0.663	m
Hospital stay (days)	7.08±2.98	6.00	9.96±5.81	9.00	0.011	m
ICU stay (days)	12 (20.0%)		21 (44.7%)		0.006	X ²
Preoperative Hb (g/dL)	13.74±1.07	13.60	11.10±1.36	11.60	0.000	m
Postoperative Hb (g/dL)	11.29±1.54	11.25	10.25±1.66	9.80	0.002	m
Preoperative Htc (%)	41.32±3.26	41.60	34.24±4.38	35.10	0.000	m
Postoperative Htc (%)	34.98±4.07	34.95	30.10±4.17	29.20	0.000	m
Preoperative INR	0.98±0.22	1.00	1.14±0.64	1.07	0.038	m
Postoperative INR	1.22±1.30	1.09	1.16±0.18	1.16	0.017	m
Preoperative Creatinine (mg/dL)	0.82±0.18	0.82	1.36±4.42	0.69	0.006	m
Postoperative Creatinine (mg/dL)	0.83±0.29	0.80	0.70±0.26	0.67	0.003	m
Preoperative Platelet (×10 ⁹ /L)	279.0±101.7	252.5	279.9±114.3	260.0	0.770	m
Perioperative bleeding (mL)	495±378	400	383±262	360	0.155	m
Perioperative fluid (mL)	1385±614	1200	1306±413	1200	0.957	m
Perioperative urine output (mL)	417.0±231.4	400.0	405.3±243.1	375.0	0.788	m

m Mann-whitney u test / X² chi-square test

Table 2. Comparison of patient outcomes and postoperative complications between ICU and ward patients.

	ICU stay (-)		ICU stay (+)		p	m
	Mean±sd/n (%)	Median	Mean±sd/n (%)	Median		
Age (years)	61.78±10.61	62.00	59.76±16.99	62.00	0.957	m
Gender						
Female	34 (45.9%)		13 (39.4%)		0.528	X ²
Male	40 (54.1%)		20 (60.6%)			
BMI	26.14±4.07		25.26±5.05		0.772	m
ASA	2.84±1.18	3.00	3.00±1.03	3.00	0.449	m
Type of surgery						
Decortication	6 (8.1%)		4 (12.1%)		0.188	X ²
Lobectomy	60 (81.1%)		22 (66.7%)			
Pneumonectomy	3 (4.1%)		5 (15.2%)			
Sleeve resection	5 (6.8%)		2 (6.1%)			
Duration of surgery (h)	3.72±1.26	4.00	4.98±1.60	4.50	0.000	m
Hospital stay (days)	6.88±3.26	6.00	11.64±5.59	11.00	0.000	m
Preoperative Hb (g/dL)	12.89±1.63	12.90	11.89±1.92	11.90	0.008	m
Postoperative Hb (g/dL)	10.89±1.65	11.05	10.72±1.73	10.10	0.683	m
Preoperative Htc (%)	39.06±4.75	39.05	36.29±5.61	36.50	0.009	m
Postoperative Htc (%)	33.52±4.83	33.80	31.31±4.29	30.40	0.023	m
Preoperative INR	1.00±0.18	1.03	1.16±0.77	1.06	0.236	m
Postoperative INR	1.22±1.18	1.11	1.13±0.16	1.14	0.369	m
Preoperative Creatinine (mg/dL)	0.77±0.20	0.74	1.71±5.26	0.77	0.410	m
Postoperative Creatinine (mg/dL)	0.76±0.25	0.74	0.81±0.35	0.75	0.597	m
Preoperative Platelet (×10 ⁹ /L)	282.5±106.8	260.0	272.5±108.4	249.0	0.761	
Perioperative bleeding volume (mL)	421.8±265.5	395.0	499.7±455.3	400.0	0.906	m
Perioperative fluid (mL)	1352±572	1200	1347±445	1200	0.712	m
Perioperative urine output (mL)	382.9±187.8	400.0	476.2±310.5	400.0	0.290	m
Intraoperative RBC (U)	2 (2.7%)		9 (27.3%)		0.000	X ²
Intraoperative FFP (U)	1 (1.4%)		3 (9.1%)		0.086	X ²
Intraoperative platelet (U)	0 (0.0%)		0 (0.0%)		-	
Postoperative RBC (U)	10 (13.5%)		7 (21.2%)		0.314	X ²
Postoperative FFP (U)	0 (0.0%)		0 (0.0%)		-	
Postoperative Platelet (U)	0 (0.0%)		0 (0.0%)		-	
Postoperative MI	0 (0.0%)		1 (3.0%)		0.318	X ²
Postoperative Arrhythmia	0 (0.0%)		0 (0.0%)		-	
Exitus	0 (0.0%)		0 (0.0%)		-	
Re-exploration	1 (1.4%)		1 (3.0%)		0.524	X ²

m Mann-whitney u test / X² chi-square test

fluid administration, perioperative urination and bleeding, and intraoperative Fresh Frozen Plasma (FFP), platelet suspension and RBC transfusion rates. Similarly, no significant difference was observed between the anemic and non-anemic groups regarding the RBC, FFP, platelet transfusion rates, Deep Vein Thrombosis (DVT), and MI as well as the rate of stroke, severe arrhythmia, mortality and re-exploration in the postoperative period ($p>0,05$, Table 1). Compared with the patients without anemia, the patients with

anemia had a significantly increased length of hospital stay, higher rate of ICU admission, higher levels of pre- and post-operative creatinine, lower levels of postoperative Hb and Htc, and lower value of preoperative INR ($p<0.05$, Table 1).

When the patients admitted to the ICU were compared with those who did not require intensive care, no significant difference was detected between the groups regarding age, gender distribution, ASA class,

Table 3. The comparison of significant effectiveness in univariable and multivariable models.

	Univariable Model			Multivariable Model		
	OR	95% confidence bounds	p	OR	95% confidence bounds	p
Duration of surgery (h)	1.9	1.3-2.7	0.000	2.0	1.4-2.9	0.000
RBC transfusion (U)	4.0	1.4-11.4	0.011			
Length of hospital stay (days)	1.3	1.2-1.5	0.000			
Preoperative Hb (mg/dL)	0.7	0.6-0.9	0.010			
Preoperative Htc (%)	0.9	0.8-1.0	0.013	0.9	0.8-1.0	0.008

Logistic Regression

type of surgery, body mass index (BMI), postoperative Hb, INR, creatinine, platelet, RBC, preoperative INR, creatinine, platelet values, perioperative fluid level, urination, bleeding, and intraoperative transfusions of FFP, and platelet suspension, postoperative DVT, MI, postoperative stroke, severe arrhythmia, and rates of mortality and re-exploration ($p > 0.05$, Table 2). Patients who required ICU admission significantly differed from those who did not, as for lower levels of preoperative Hb, pre- and postoperative Htc levels and increased duration of operation, hospital stay, and higher intraoperative RBC use ($p < 0.05$, Table 2).

In the univariate model, the duration of surgery and hospital stay, the amount of intraoperative RBC transfusion, preoperative Hb and Htc levels had a significant effectiveness ($p < 0.05$). In the multivariate model, the duration of surgery and preoperative Htc values were independent effective factors ($p < 0.05$, Table 3).

DISCUSSION

In the present study, preoperative anemia was found to be associated with extended length of stay at hospital and ICU. In the anemic group, the perioperative creatinine level was significantly higher, and the duration of surgery and the total length of hospital stay were longer in the patients admitted to intensive care unit.

Preoperative anemia is a common condition in patients undergoing major elective surgery. The most common reason in the etiology of preoperative anemia is iron deficiency^[10,11]. Iron deficiency anemia, anemia of chronic disease, and iatrogenic anemia are three most common causes in patients undergoing thoracic surgery^[12]. We included the patients who had decortication, lobectomy, pneumonectomy, and sleeve lobectomy in this study. These patients generally had chronic diseases such as cancer in etiology. The major causes of anemia in lung disease-related cancers include impaired intestinal iron absorption and reduced bone marrow response to erythropoietin^[13].

Preoperative anemia increases the incidence of mortality in both adult and pediatric patients^[14]. One of the main causes of the increase in mortality is the elevation in the frequency of blood and blood product transfusions. Neither the anemic nor the non-anemic groups showed a significant rise in the intraoperative or postoperative levels of RBC, FFP or the use platelets. Furthermore, the incidence of the complications including postoperative MI, arrhythmias, re-exploration or exitus was also similar between the groups. We, however, identified that the most significant adverse result of anemia in patients undergoing thoracic surgery is extended length of hospital and ICU stays. Our study also indicated that the patients admitted to the ICU experienced longer hospital stay, longer operative times and increased use of intraoperative RBC. It may be specula-

ted whether anemia in the study cohort may represent a marker for more sick patients rather than an isolated reduction in hemoglobin mass.

A study analyzing the data on 189 patients having pulmonary resection demonstrated an increased incidence of respiratory and infectious complications in anemic patients ^[15]. The Enhanced Recovery After Surgery (ERAS) protocol aiming to identify and eliminate patients' nutritional deficits in the preoperative period has been put into practice ^[16]. This protocol enables the optimization of patients before surgery including preoperative treatment of anemia, and thereby, facilitates the operation of patients.

Preoperative and intraoperative anemia has been identified as a risk factor for acute kidney injury (AKI) ^[17]. In the present study, we followed up the perioperative creatinine clearance and urine output levels. Whereas perioperative urine output did not significantly differ between groups, perioperative creatinine levels were found to be significantly higher in the anemic group. The incidence of AKI has been reported to be high in cardiac surgeries and transplantations procedures ^[18]. This study proves that preoperative anemia is associated with AKI in thoracic surgeries. This addresses that microcirculation perfusion can not be adequately maintained in anemic patients.

In recent years, there have been studies reporting that blood transfusion increases the chance of recurrence in patients undergoing surgery for lung cancer ^[19]. In fact, this is a controversial issue as there are also studies arguing that blood transfusion has no effect on recurrence. However, it is unquestionable that patients that have preoperative anemia before pulmonary resection and thus receive blood transfusion develop poor outcomes. The direct growth factor action plays a key role on transfusion-associated immune suppression and lung cancer cells ^[20].

Limitations

Our study has some limitations due to its retrospec-

tive nature. In our analyses, we did not include different types of surgical procedures such as mediastinoscopy, which might influence the study results. The low number of the patients, whose complete medical data we were able to access, was also a limitation.

Conclusion

Consequently, the incidence of preoperative anemia was found to be higher (43.9%) in patients undergoing pulmonary resection. It was determined that even though preoperative anemia did not generally cause a significant increase in the mortality rate or create a risk for perioperative blood transfusion, it extended the length of hospital and ICU stays and it is an important predictor associated with AKI development. In this regard, we believe that the treatment of preoperative anemia should be considered to reduce anemia-induced perioperative complications for thoracic surgery patients.

REFERENCES

1. Elhenawy AM, Meyer SR, Bagshaw SM, MacArthur RG, Carroll LJ. Role of preoperative intravenous iron therapy to correct anemia before major surgery: study protocol for systematic review and meta-analysis. *Syst Rev* 2015;4:29. <https://doi.org/10.1186/s13643-015-0016-4>
2. Chamogeorgakis T, Anagnostopoulos C, Kostopanagiotou G, Bhora F, Toumpoulis I, Georgiannakis E, et al. Does anemia affect outcome after lobectomy or pneumonectomy in early stage lung cancer patients who have not received neo-adjuvant treatment? *Thorac Cardiovasc Surg*. 2008;56(3):148-53. <https://doi.org/10.1055/s-2007-989455>
3. Yovino S, Kwok Y, Krasna M, Bangalore M, Suntharalingam M. An association between preoperative anemia and decreased survival in early-stage non-small-cell lung cancer patients treated with surgery alone. *Int J Radiat Oncol Biol Phys*. 2005;62(5):1438-43. <https://doi.org/10.1016/j.ijrobp.2004.12.038>
4. Ludwig H, Van Belle S, Barrett-Lee P, Birgegård G, Bokemeyer C, Gascón P, et al. The European Cancer Anaemia Survey (ECAS): a large, multinational, prospective survey defining the prevalence, incidence, and treatment of anaemia in cancer patients. *Eur J Cancer*. 2004;40(15):2293-306. <https://doi.org/10.1016/j.ejca.2004.06.019>
5. Auerbach M. Intravenous iron in the perioperative setting. *Am J Hematol* 2014;89(9):933. <https://doi.org/10.1002/ajh.23793>
6. Muñoz M, Gómez-Ramírez S, Campos A, Ruiz J,

- Liumbruno GM. Pre-operative anaemia: prevalence, consequences and approaches to management. *Blood Transfus* 2015;13:370-9.
<https://doi.org/10.2450/2015.0014-15>.
7. Jean RA, DeLuzio MR, Kraev AI, Wang G, Boffa DJ, Detterbeck FC, et al. Analyzing Risk Factors for Morbidity and Mortality after Lung Resection for Lung Cancer Using the NSQIP Database. *J Am Coll Surg*. 2016 Jun;222(6):992-1000.e1.
<https://doi.org/10.1016/j.jamcollsurg.2016.02.020>
 8. Tomita M, Shimizu T, Hara M, Ayabe T, Onitsuka T. Preoperative leukocytosis, anemia and thrombocytosis are associated with poor survival in non-small cell lung cancer. *Anticancer Res* 2009;29(7):2687-90.
 9. World Health Organization. Iron deficiency anaemia: assessment, pre-vention, and control: 2001. Available at: http://whqlibdoc.who.int/hq/2001/WHO_NHD_01.3.pdf. Accessed November 21, 2007.
 10. Piednoir P, Allou N, Driss F, Longrois D, Philip I, Beaumont C, Montravers P, Lasocki S. Preoperative iron deficiency increases transfusion requirements and fatigue in cardiac surgery patients: a prospective observational study. *Eur J Anaesthesiol*. 2011;28(11):796-801.
<https://doi.org/10.1097/EJA.0b013e32834ad97b>
 11. Desai N, Schofield N, Richards T. Perioperative patient blood management to improve outcomes. *Anesth Analg*. 2018;127(5):1211-20.
<https://doi.org/10.1213/ANE.0000000000002549>
 12. Karski JM, Mathieu M, Cheng D, Carroll J, Scott GJ. Etiology of preop- erative anemia in patients undergoing scheduled cardiac surgery. *Can J Anaesth*. 1999;46(10):979-82.
<https://doi.org/10.1007/BF03013135>
 13. Jans Ø, Jørgensen C, Kehlet H, Johansson PI; Lundbeck Foundation Centre for Fast-track Hip and Knee Replacement Collaborative Group. Role of preoperative anemia for risk of transfusion and postoperative morbidity in fast-track hip and knee arthroplasty. *Transfusion* 2014;54(3):717-26.
<https://doi.org/10.1111/trf.12332>
 14. Faraoni D, DiNardo JA, Goobie SM. Relationship Between Preoperative Anemia and In-Hospital Mortality in Children Undergoing Noncardiac Surgery. *Anesth Analg* 2016;123(6):1582-7.
<https://doi.org/10.1213/ANE.0000000000001499>
 15. Fernandes EO, Teixeira C, Silva LC. Thoracic surgery: risk factors for postoperative complications of lung resection. *Rev Assoc Med Bras (1992)* 2011;57(3):292-8.
<https://doi.org/10.1590/S0104-42302011000300011>
 16. Huang H, Ma H, Chen S. Enhanced recovery after surgery using uniportal video-assisted thoracic surgery for lung cancer: A preliminary study. *Thorac Cancer* 2018;9(1):83-7.
<https://doi.org/10.1111/1759-7714.12541>
 17. Duque-Sosa P, Martínez-Urbistondo D, Echarri G, Callejas R, Iribarren MJ, Rábago G, et al; Spanish group of renal dysfunction in cardiac surgery (GEDRCC-2). Perioperative hemoglobin area under the curve is an independent predictor of renal failure after cardiac surgery. Results from a Spanish multicenter retrospective cohort study. *PLoS One* 2017;12(2):e0172021.
<https://doi.org/10.1371/journal.pone.0172021>
 18. Goren O, Matot I. Update on perioperative acute kidney injury. *Curr Opin Crit Care* 2016;22(4):370-8.
<https://doi.org/10.1097/MCC.0000000000000318>
 19. Churchhouse AM, Mathews TJ, McBride OM, Dunning J. Does blood transfusion increase the chance of recurrence in patients undergoing surgery for lung cancer? *Interact Cardiovasc Thorac Surg*. 2012;14(1):85-90.
<https://doi.org/10.1093/icvts/ivr025>
 20. Cata JP, Gutierrez C, Mehran RJ, Rice D, Nates J, Feng L, Rodriguez-Restrepo A, Martinez F, Mena G, Gottumukkala V. Preoperative anemia, blood transfusion, and neutrophil-to-lymphocyte ratio in patients with stage i non-small cell lung cancer. *Cancer Cell Microenviron* 2016;3(1):e1116.
<https://doi.org/10.14800/ccm.1116>