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Restrictive Blood Transfusion Protocol in Malignant Upper Gastrointestinal and Pancreatic Resections Patients Reduces Blood Transfusions with No Increase in Patient Morbidity

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Abstract

Background—The purpose of this study was to determine the impact of a restrictive blood transfusion protocol on the number of transfusions performed and the related effect on patient morbidity.

Methods—A cohort study was performed using our prospective database with information from 01/01/2000–06/01/2013. The restrictive blood transfusion protocol was implemented in 9/2011, so this date served as the separation point for the date of operation criteria.

Results—For the study, 415 patients undergoing operation for an abdominal malignancy were reviewed. Following the restrictive blood transfusion protocol the percentage of patients that received blood dropped from 35.6% to 28.3%. The percentage of patients that experienced perioperative complication was significantly higher in transfused patients compared to those that did not receive blood ($p=0.0001$). There was no statistical significance observed between the four groups for the length of stay at the hospital following their procedure.

Conclusion—The restrictive blood transfusion protocol resulted in a reduction of the percentage of patients transfused, and there was no evidence to suggest that it negatively impacted the outcomes of patients in this group.

Keywords

Esophagectomy; Gastrectomy; Hepatectomy; Pancreatectomy; blood transfusion; complications

INTRODUCTION

The proper management of anemia in the field of surgical oncology is crucial to optimizing care for these patients. The incidence, consequences, and causation of anemia in this patient

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population have been studied, and the effects of blood transfusion as a treatment have been documented.^{1, 2, 3} Allogeneic blood transfusions in the perioperative period have been shown to negatively impact overall patient outcomes by increasing morbidity and cancer recurrence.^{4, 5, 6, 7} The mechanism of this association is not completely understood, but it has been suggested that a process known as transfusion-related immunomodulation (TRIM) is responsible for the observed negative effects caused by transfusion.⁸

While the evidence contraindicating the need for transfusion is widely accepted, there still remain instances where transfusion is absolutely necessary for the patient's recovery and survival. Wu et al⁹ showed that with significant intraoperative blood loss and hematocrit levels less than 24%, patients that received a blood transfusion had decreased 30-day mortality. In the same study, transfusion was associated with an increase in mortality in patients with hematocrit levels between 30% and 35.9% and intraoperative blood loss of less than 500mL.

The relationship between risk and benefit appears to be a balance between several factors, but in theory, restriction of the triggers for transfusion should help eliminate unnecessary transfusions and ultimately improve patient outcomes. In this study, we examined the effects of a dedicated restrictive transfusion protocol, and we hypothesized that the protocol would reduce the rate of transfusions without increasing patient morbidity.

METHODS

A literature review was performed to gather background information pertaining to the subject of blood transfusions in surgical oncology patients. Pubmed, EBSCO, and Ovid were used as the primary search engines for the review. The search criteria included the phrase "blood transfusion" in the title or abstract and the terms "surgery" and "cancer" mentioned within the text of the article. To further refine the results, articles were only included if they were published within the last five years in English with humans as the subjects of the study. The parameters of this search produced 58 results on Pubmed, 107 results on EBSCO, and 113 results on Ovid. Articles that were not used as resources for this study were eliminated based on their relevance to the topic of perioperative blood transfusions in patients undergoing an operation for an abdominal malignancy. Seventeen articles remained after the elimination of irrelevant articles and duplicates. This process is demonstrated visually in Figure #1.

A review was performed using our prospective database with data from 01/01/2000 to 06/01/2013. The patients included in this study underwent a surgical procedure involving an abdominal malignancy, and the patients from the database that did not meet this criterion were excluded. There were a total of five different procedures performed on the patients in this study, and these were hepatectomy, total gastrectomy, partial gastrectomy, pancreaticoduodenectomy (Whipple), and distal pancreatectomy. Standard pre-operative comorbidities were recorded including cardiac (i.e. history of MI > 6 months from index surgery, or history of CABG, etc.), pulmonary, renal, hepatic, prior surgeries, and any other past medical or surgical history.

Prior to implementation of this restrictive blood transfusion protocol, there was no consensus, guidelines, or oversight on the use of blood transfusion in regards to when to transfuse or how much to transfuse. A restrictive blood transfusion protocol was implemented in September of 2011. The restrictive protocol set the transfusion trigger for hemodynamically stable patients at hemoglobin of 7g/dL with goal hemoglobin of 7–9g/dL. An exception to the protocol included patients with a cardiac comorbidity, such as evidence of myocardial ischemia. Patients with chemotherapy associated anemia were given epoetin or darbepoetin as their hemoglobin approached or fell below 10g/dL, but if no response was noted after 6–8 weeks, these agents were discontinued. Patients with coagulopathic bleeding (defined as a condition in which the blood's ability to clot is impaired) or an INR greater than 2.0 (defined as risk of bleeding) were recommended to receive plasma transfusion. Fresh frozen plasma transfusion was indicated for rapid reversal of warfarin and in patients with a risk of serious bleeding and an INR greater than 1.5. Vitamin K was used for the reversal of warfarin in cases that were not urgent. Platelet transfusion was indicated in patients with platelet counts less than 10,000 or in patients with platelets counts less than 50,000 experiencing excessive bleeding. Platelet transfusion was not indicated in patients with counts greater than 100,000 and normal platelet function. Cryoprecipitate administration was considered for patients with fibrinogen concentration less than 100mg/dL and coagulopathic bleeding or in cases of uremic bleeding.

Since the restrictive blood transfusion protocol took effect in September of 2011, September 1st, 2011 served as the separation point for patient data in this study. The sample size within the database before the implementation of the protocol was much larger. To make the groups before and after the protocol implementation more comparable data sets, cases before 09/01/2009 were not considered in this study.

RESULTS

A total of 415 patients were included in this study and were subsequently divided into four groups based on the date of their operation and whether or not they received a transfusion. Patients that received an operation between 09/01/2009 and 09/01/2011 and did not have a transfusion will be referred to as “Pre-Transfusion Protocol No Blood.” This group contained 174 patients. Patients that had an operation during this time frame and received a transfusion will be referred to as “Pre-Transfusion Protocol Blood.” There were 96 patients in this group. For patients that underwent an operation from 09/01/2011–05/23/2013, those that did not receive a transfusion were included in the group called “Post-Transfusion Protocol No Blood,” and those that received blood were included in the “Post-Transfusion Protocol Blood” group. There were 104 patients in the “Post-Transfusion Protocol No Blood” group and 41 patients in the “Post-Transfusion Protocol Blood” group.

The data for the baseline characteristics of the patients is provided in Table #1. The average age of the patients ranged between the four groups from a low of 60.8 years old in “Pre-Transfusion Protocol No Blood” to a high of 65.2 years old in “Post-Transfusion Protocol Blood.” The average ages for “Pre-Transfusion Protocol Blood” and “Post-Transfusion Protocol No Blood” were 64.8 years old and 62.9 years old, respectively. There was a significant difference in age between all patients that did not receive blood compared to

those that did ($p=0.016$). The average BMI was higher in both groups before the protocol with an average BMI of 28.0 in "Pre-Transfusion Protocol No Blood" and 28.9 in "Pre-Transfusion Protocol Blood." The average BMI for "Post-Transfusion Protocol No Blood" was 27.4, which was greater than the average BMI of 26.9 in "Post-Transfusion Protocol Blood." No statistical significance was found between any of the groups for BMI, gender, or race/ethnicity. The percentage of patients with cardiac comorbidity was greater in both groups that received blood compared to their "No Blood" counterparts, and this difference was significant when comparing all patients that did not receive a transfusion with all that did ($p=0.006$). The percentage of patients with cardiac comorbidity was also significantly higher in "Pre-Transfusion Protocol Blood" compared to "Pre-Transfusion Protocol No Blood" ($p=0.018$). The presence of a pulmonary comorbidity was noted in 19.8% of the patients in "Pre-Transfusion Protocol Blood," which was almost 10% higher than the next highest value. The difference in the percentage of patients with pulmonary comorbidity was significant when comparing all patients that received blood versus those that did not ($p=0.031$), "Pre-Transfusion Protocol Blood" versus "Pre-Transfusion Protocol No Blood" ($p=0.013$), and "Pre-Transfusion Protocol Blood" versus "Post-Transfusion Protocol Blood" ($p=0.050$). In addition to the highest percentages for cardiac and pulmonary comorbidities, "Pre-Transfusion Protocol Blood" also had the highest percentage of patients that reported using tobacco, 36.5%. This was significantly higher than the percentage of patients within the "Post-Transfusion Protocol Blood" group, which was 17.1% ($p=0.040$). Of the four groups, the highest median platelet count, 248.0, was seen in "Pre-Transfusion Protocol Blood." This value was significantly higher than in "Post-Transfusion Protocol Blood" with a p -value of 0.029. As expected, median hemoglobin levels were significantly lower in the "Blood" groups compared to the "No Blood" groups. The data comparing hemoglobin for "Pre-Transfusion Protocol Blood" and "Post-Transfusion Protocol Blood" was not significantly different, but it was lower in "Post-Transfusion Protocol Blood," 12.0g/dL versus 11.6g/dL. The creatinine values were lowest in "Post-Transfusion Protocol Blood," and the difference was significant when "Post-Transfusion Protocol Blood" was compared to "Pre-Transfusion Protocol Blood" ($p=0.016$). In a multi-variable evaluation of just the statistically significant variables Age ($p=0.391$), Cardiac ($p=0.195$) were not statistically significant for blood transfusion in the entire group. Only pre-op hemoglobin ($p=0.002$, HR 3.2 – CI 1.5 – 5.6) was significant in predicting the use of blood transfusion during the patients hospital stay.

Table #2 presents operative data for the procedures performed on the patients. The percentage of patients that were transfused was not significantly different before and after the implementation of the restrictive protocol, but a reduction in this percentage was noted. Before the protocol, 35.6% of patients received a transfusion, whereas only 28.3% of patients were transfused after the protocol was put in place. The median number of units transfused before and after the protocol was the same, 2.0. The median blood loss of 600.0mL was the same for both transfused groups, and this value was greater than the median blood loss for both of the "No Blood" groups. The median operative time was also greater in the "Blood" groups compared to the "No Blood." Between the "Blood" groups, the median operative time for "Post-Transfusion Protocol Blood" was significantly longer than "Pre-Transfusion Protocol Blood" ($p=0.000$). The grade of the operation performed on

patients was more severe in those that were transfused compared to those that were not. The difference was significant when comparing the "Blood" group to the "No Blood" group and also for "Pre-Transfusion Protocol Blood" and "Pre-Transfusion Protocol No Blood" ($p=0.021$; $p=0.017$, respectively). The disease characteristics (number of tumors, size of largest tumor, and tumor margin) did not show significance related to the implementation of the restrictive transfusion protocol.

Table #3 includes the outcome data for the patients in this study. The percentage of patients that experienced perioperative complication was significantly higher in transfused patients compared to those that did not receive blood ($p=0.000$). Although the results were not significant, both groups of patients before the protocol implementation had higher percentages of complication compared to their counterparts after the protocol was implemented. "Post-Transfusion Protocol Blood" patients had the highest incidence of infection after their procedure (21.2%). This percentage was significantly higher than the "Pre-Transfusion Protocol Blood" group, which had an infection rate of 4.6% ($p=0.002$). There was no statistical significance observed between the four groups for the length of stay at the hospital following their procedure. However, both "Blood" groups had an average length of stay that was longer than the "No Blood" groups, and length of stay for "Post-Transfusion Protocol Blood" was longer than "Pre-Transfusion Protocol Blood," 13.1 days compared to 12.1 days.

DISCUSSION

The purpose of this study was to determine if a restrictive blood transfusion protocol would reduce the overall number of patients transfused without negatively impacting patients' outcomes. As shown in Table #2, the percentage of patients that received a transfusion was reduced by 7.3% following the implementation of the restrictive protocol. Table #3 provided evidence supporting the theory that this reduction would not have a negative effect on overall outcomes. In fact, the results of this study suggest a slight improvement in outcomes after the protocol was adopted. This was best seen in the disease status of the patients, where the percentage of patients that either died from their disease or died from other causes was 13.0% before the protocol compared to only 6.2% after the protocol. We believe this is in direct relation to the restrictive blood transfusion protocol since there has not been a change in surgical technique or patient selection. Similarly, in a review of "Pre-Transfusion Protocol Blood" patients this restrictive protocol would have reduced blood transfusion in 14.5% of those patients who were transfused.

In addition to the percentage of transfusions and disease status of the patients, there are other values in the data that also suggest the success of the restrictive protocol. These values include factors, such as hemoglobin levels, total blood loss, and operative time, which are traditionally believed to be predictive for administering a transfusion.^{10, 11, 12, 13}

The hemoglobin levels reported in Table #1 show a reduction in the median value from 12.0g/dL to 11.6g/dL in "Pre-Transfusion Protocol Blood" compared to "Post-Transfusion Protocol Blood." Although the difference was not significant, the drop in hemoglobin levels between these two groups suggests that the patients selected for a transfusion by the

restrictive protocol were more anemic than those indicated for transfusion before the protocol.

The median values for total blood loss were the same for "Pre-Transfusion Protocol Blood" and "Post-Transfusion Protocol Blood" at 600.0mL, which does not appear to be meaningful in terms of the indication for transfusion. However, the difference in median total blood loss between the two "No Blood" groups shows an increase of 64.5mL in the group of patients that were not transfused after the protocol. The possible explanation for this increase is that the restrictive protocol contraindicated transfusing some patients whose total blood loss may have previously recommended giving blood.

The median operative time was longest in "Post-Transfusion Protocol Blood" and was significantly longer than the median operative time for "Pre-Transfusion Protocol Blood" with a p-value of 0.000. The increase in the operative time for "Post-Transfusion Protocol Blood" is further evidence that the restrictive protocol only indicated the need for transfusion in more emergent situations. This conclusion is supported by findings of a study performed by Ojima et al¹³ in 2009, which stated that long duration of operation is a prognostic factor for blood transfusion.

For this study, cardiac and pulmonary comorbidities were significantly higher in transfused patients, but the values did not indicate a change related to the restrictive transfusion protocol. The lack of a difference between the "Blood" groups actually supports the methods of the protocol, which states that restricting the transfusion trigger in patients with these comorbidities is contraindicated. Comorbidities have widely been shown to be prognostic indicators for receiving a transfusion, and in this study, the significant difference of comorbidities between the "No Blood" and "Blood" groups supports this theory.^{10, 14}

The data for rates of new disease recurrence in this study contradict the results from several other studies which have indicated that blood transfusions increase the risk for disease recurrence and progression.^{15, 16, 17} The highest rates of new recurrence were seen in "Pre-Transfusion Protocol No Blood," which had new recurrence in 17.8% of patients, and the lowest percentage of new recurrence was 7.7% for "Pre-Transfusion Protocol Blood."

The process by which transfusions affect disease recurrence has been hypothesized as an immunosuppressive reaction to the transfused blood. In a 2007 review, Vamvakas et al⁸ described a process called "transfusion-related immunomodulation" (or TRIM), which is believed to be modulated by three potential mechanisms based on the results of other studies. These three mechanisms include clonal deletion of alloreactive lymphocytes, anergy, and immunosuppression via cellular mechanisms or cytokines. Mikki et al⁷ proposed a similar relationship between blood transfusions and an immune response contributing to worse long-term survival and disease recurrence. The results of their study showed elevated levels of interleukin-6 (IL-6), a pro-inflammatory cytokine, in patients that received an allogeneic blood transfusion due to excessive intraoperative blood loss. Another study conducted by Ferraris et al¹⁸ concluded that there is a significant association between transfusions and a systemic inflammatory response, also mediated by cytokines.

Studies are currently examining alternative techniques to blood transfusion in response to the information demonstrating the scope of its negative effects (Table #4). The use of autologous blood donation has been considered as a possibility because in theory, patients should not develop an immune response to the transfusion if they are receiving their own blood. This technique was tested with positive results in a study done by Tomimaru et al¹⁹. The study demonstrated that autologous blood transfusion can reduce the need for homologous blood transfusion and can potentially improve long-term outcomes in patients treated for hepatocellular carcinoma. Intravenous iron has also been studied as a possible therapy to reduce the need for blood transfusion, but the efficacy of this treatment remains unproven in the published literature. A randomized controlled trial from 2009 was not able to prove an association between intravenous iron sucrose and an increase in preoperative hemoglobin.²⁰ However, a more recent meta-analysis from 2013 provided more hopeful results for the effectiveness of intravenous iron increasing preoperative hemoglobin levels and decreasing risk of perioperative blood transfusion.²¹ Unfortunately, the meta-analysis also concluded that there was a correlation between the iron therapy and postoperative infection, which limits its overall benefit as a viable alternative for blood transfusions.

Limitations in the design of this study mostly focused on the size of the cohort following the implementation of the restrictive blood transfusion protocol. Ideally, studies of this nature will have divided the patients into groups of equal size, but unfortunately, there were not enough patients that could be included for "Post-Transfusion Protocol No Blood" and "Post-Transfusion Protocol Blood." The smaller groupings following the protocol may have skewed some of the data to indicate there was or was not significance. When in fact, the results would have shown the opposite to be true had the study been performed with a larger population of patients. However all of the surgical resections included in this study, hepatectomies, total and partial gastrectomies, and pancreatectomies are all considered major abdominal surgery regardless of the extent of the organ that is resected, thus demonstrating these results do have broad clinical applicability and interpretation. For this reason, this study should be repeated in the future after more patients have been treated in accordance with the restrictive protocol in order to determine if the conclusions made here are correct. Given the reduction in blood transfusion with the use of this protocol, we have estimated that an additional 283 patients will need to be evaluated and followed following surgical therapy.

In conclusion, a restrictive blood transfusion protocol effectively reduced the number of blood transfusions performed, and the reduction in transfusions was not associated with an increase in patient morbidity or mortality. Several factors should be considered when applying the principles of a restrictive transfusion protocol to ensure that patients in need of a transfusion are treated accordingly. If the process is followed correctly, data from the published literature and the results of this study suggest that there should be a reduction in the rate transfusions and the associated complications.

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Figure #1.

Table #1

Baseline Patient Characteristics Before and After Protocol

	9/2009-9/2011 No Transfusion (n=174)	9/2009-9/2011 Received Transfusion (n=96)	After 9/2011 No Transfusion (n=104)	After 9/2011 Received Transfusion (n=41)	P-values
Age	60.8	64.8	62.9	65.2	0.016 [*] , 0.063 [†]
BMI	28.0	28.9	27.4	26.9	
Gender					
Male	55.7% (97)	52.1% (50)	46.2% (48)	48.8% (20)	
Female	44.3% (77)	47.9% (46)	53.8% (56)	51.2% (21)	
Race/Ethnicity					
White (non-Hispanic)	85.1% (148)	87.5% (85)	78.8% (82)	80.5% (33)	
Black	9.2% (16)	8.3% (8)	7.7% (8)	12.2% (5)	
Other	1.1% (2)	1.0% (1)	4.8% (5)	0.0%	
Past Medical History					
Cardiac Comorbidity	19.5% (34)	33.3% (32)	12.5% (13)	19.5% (8)	0.006 [*] , 0.018 [†]
Pulmonary Comorbidity	9.8% (17)	19.8% (19)	4.8% (5)	4.9% (2)	0.031 [*] , 0.013 [†] , 0.050 [‡]
Diabetes	17.2% (30)	16.7% (16)	10.6% (11)	17.1% (7)	
Alcohol	12.1% (21)	10.4% (10)	7.7% (8)	7.3% (3)	
Tobacco	28.7% (50)	36.5% (35)	18.3% (19)	17.1% (7)	0.040 [‡]
Hepatic	3.4% (6)	11.5% (11)	2.9% (3)	7.3% (3)	0.007 [*] , 0.016 [†]
Pancreatitis	1.1% (2)	2.1% (2)	2.9% (3)	4.9% (2)	
Past Surgical History					
Total Abdominal Hysterectomy	10.3% (18)	12.5% (12)	19.2% (20)	7.3% (3)	
Cholecystectomy	18.4% (32)	18.8% (18)	15.4% (16)	14.6% (6)	
Colon	10.3% (18)	7.3% (7)	11.5% (12)	14.6% (6)	
Appendectomy	6.3% (11)	2.1% (2)	4.8% (5)	2.4% (1)	
Orthopedic	16.1% (28)	15.6% (15)	20.2% (21)	9.8% (4)	
PreOp Chemotherapy	22.5% (39)	11.6% (11)	16.8% (17)	32.5% (13)	0.066 [†] , 0.033 [‡]
Blood Lab Values					

	9/2009–9/2011 No Transfusion (n=174)	9/2009–9/2011 Received Transfusion (n=96)	After 9/2011 No Transfusion (n=104)	After 9/2011 Received Transfusion (n=41)	P-values
Platelets	226.0	248.0	228.0	206.0	0.029 ^δ
Hemoglobin	13.4	12.0	13.1	11.6	0.000 [*] , 0.008 [‡] , 0.000 [‡]
Creatinine	0.9	0.9	0.9	0.7	0.016 ^δ

^{*} all patients that received blood compared to all patients that did not receive blood

[‡] patients after the protocol that received blood compared to patients after the protocol that did not receive blood

[‡] patients before the protocol that received blood compared to patients before the protocol that did not receive blood

^δ patients before the protocol that received blood compared to patients after the protocol that received blood

Table #2

Operative Data Before and After Protocol

	9/2009–9/2011 No Transfusion (n=174)	9/2009–9/2011 Received Transfusion (n=96)	After 9/2011 No Transfusion (n=104)	After 9/2011 Received Transfusion (n=41)	P-values
Blood Transfusions	64.4%	35.6%	69.0%	28.3%	
Number of Units Transfused	N/A	2.0	N/A	2.0	
Total Blood Loss	250.0	600.0	314.5	600.0	0.000 [§]
Operative Time	140.0	175.0	144.1	222.5	0.000 [§]
Grade of Operation					0.021 [*] 0.017 [‡]
Minor	19.0% (33)	10.4% (10)	16.3% (17)	4.9% (2)	
Moderate	21.8% (38)	15.6% (15)	17.3% (18)	22.0% (9)	
Major	38.5% (67)	37.5% (36)	39.4% (41)	31.7% (13)	
Major + Another Procedure	20.7% (36)	36.5% (35)	26.9% (28)	41.5% (17)	
Preoperative Intent					
Cure	89.8% (156)	93.1% (84)	90.7% (94)	100.0%	
Palliation	10.2% (18)	6.9% (12)	9.3% (10)	0.0%	
Number of Tumors	1.0	1.0	1.3	1.3	0.037 [‡]
Size of Largest Tumor	3.2	3.5	3.7	4.3	
Defined Tumor Margin	15.0% (16)	12.9% (12)	13.7% (14)	28.6% (12)	

^{*} all patients that received blood compared to all patients that did not receive blood

[‡] patients after the protocol that received blood compared to patients after the protocol that did not receive blood

[‡] patients before the protocol that received blood compared to patients before the protocol that did not receive blood

[§] patients before the protocol that received blood compared to patients after the protocol that received blood

Table #3

Outcome Data Before and After Protocol

	9/2009-9/2011 No Transfusion (n=174)	9/2009-9/2011 Received Transfusion (n=96)	After 9/2011 No Transfusion (n=104)	After 9/2011 Received Transfusion (n=41)	P-value
Complication	36.8% (64)	58.8% (56)	22% (23)	45.5% (15)	0.000 [*] , 0.021 [†]
Intraoperative Surgical Complication					
None	98.9% (172)	96.9% (93)	99% (103)	95.1% (39)	
Hemorrhage	0.6% (1)	2.1% (2)	0.0%	2.4% (1)	
Hypotensive Episode	0.6% (1)	1% (1)	1% (1)	2.4% (1)	
Grade of Complication					
Oral Antibiotics	20.3% (12)	2.1% (1)	20% (3)	0.0%	
IV Antibiotics	50.8% (30)	31.3% (15)	40% (6)	9.1% (1)	
Return to ICU					
Percutaneous Drainage					
Operative Correction	25.4% (15)	54.2% (26)	20% (3)	72.7% (8)	
Organ Diversion	0.0%	0.0%	0.0%	0.0%	
Death	0.0%	4.2% (2)	13.3% (2)	18.2% (2)	
Infection	7.3% (11)	4.6% (4)	7.6% (1)	21.2% (9)	0.002 [§]
Length of Stay	8.4	12.1	7.1	13.1	
New Recurrence	17.8% (31)	7.7% (7)	10.2% (11)	11.1% (5)	
Karnofsky Score	100	95	100	100	0.025 [§]
Status					
No Evidence of Disease	57.7% (100)	50.5% (46)	67.4% (58)	50% (20)	
Alive with Disease	31.9% (55)	30.8% (28)	26.7% (23)	36.1% (16)	
Died of Disease	9.2% (16)	7.7% (7)	2.3% (2)	0.0%	
Died of Other Cause	1.2% (2)	11% (10)	2.3% (2)	13.9% (5)	

* all patients that received blood compared to all patients that did not receive blood

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patients after the protocol that received blood compared to patients after the protocol that did not receive blood
patients before the protocol that received blood compared to patients before the protocol that did not receive blood
patients before the protocol that received blood compared to patients after the protocol that received blood

Table

Review of Current Literature Evaluating Reported Data Related to Perioperative Blood Transfusions

	Hemoglobin Levels (g/dL)	Blood Loss (mL)	Tumor Size (cm)	Operative Time	30-Day Mortality	30-Day Morbidity	Non-Bleeding Complications	Complications (not specified)
Article #1 - Al-Refaie 2012	-	-	-	-	1.7% (not transfused)/4.8% (1-2U)/7.8% (>3U)	-	-	-
Article #3 - McNally 2011	-	800	-	-	-	-	-	33%
Article #4 - Bernard 2009	-	-	-	-	1.4%	11.10%	-	-
Article #7 - Cannon 2013	-	533 (transfused); 293 (not transfused)	-	-	-	-	42.70%	-
Article #9 - Froman 2012	8.4 (post-op, not transfused)/7.3 (post-op, transfused)	-	-	166 minutes	-	-	-	-
Article #12 - Sima 2009	13.5 (not transfused)/12.8 (transfused)	-	-	-	-	-	-	-
Article #14 - Wu 2010	-	-	-	3.8h (transfused)/2.8h (not transfused)	-	-	-	-
Article #15 - Yeh 2007	< 12 (transfused)	> 700 (transfused)	-	-	-	-	-	-
Article #21 - Cockbain 2010	< 12.5 (transfused)	-	> 3.5	-	-	-	-	-
Article #24 - Ferraris 2012	-	-	-	-	1.1% (not transfused)/6.3% (transfused)	11.8% (not transfused)/34.6% (transfused)	-	-
Article #30 - Scott 2008	-	-	-	8h (transfused)/4.3h (not transfused)	3.1% (transfused)	-	-	-