Journal of Plastic, Reconstructive & Aesthetic Surgery (2019) 72, 1616–1622

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Predictors of blood transfusion in autologous breast reconstruction surgery: A retrospective study using the nationwide inpatient sample database☆

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Received 16 January 2019; accepted 9 June 2019

KEYWORDS
Predictors;
Blood Transfusion;
Breast reconstruction

Summary *Background:* Specific risk factors associated with the use of blood transfusions during and following autologous breast reconstruction are unknown. The purpose of this study was to evaluate the rate of blood transfusion in autologous breast reconstruction and identify independent risk factors of blood transfusion in autologous breast reconstruction.
Materials: A cohort of patients who had undergone autologous breast reconstruction was identified using the Nationwide Inpatient Sample database from 2012 to 2014 in the United States. Univariate and multivariate regression analyses were performed to identify independent risk factors of blood transfusion in this patient population.
Results: A total of 55,840 patients underwent autologous breast reconstruction surgery during this period. The overall rate of blood transfusion was 7.0%. Multivariate regression analysis showed that chronic anemia (adjusted odds ratio [AOR], 5.17), congestive heart failure (AOR, 4.07), free flap (AOR, 2.03), chronic kidney disease (AOR, 1.79), hypertension (AOR, 1.39), chronic lung disease (AOR, 1.23), diabetes mellitus (AOR, 1.21), non-teaching hospital (AOR, 1.20), and obesity (AOR, 1.12) were significant risk factors of blood transfusion. There was no association between age, race, liver disease, smoking, chemotherapy, or reconstruction-time

☆ Parts of this article have been presented at the following meetings/conferences: 1. Presented as a poster presentation at the American Society for Reconstructive Microsurgery Annual Meeting, January 13–16, 2018 at Phoenix, Arizona. 2. Presented as a podium presentation at the Texas Society of Plastic Surgery Annual Meeting, September 14–16, 2018 at San Antonio, Texas.

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https://doi.org/10.1016/j.bjps.2019.06.012

on blood transfusion. Patients who received blood transfusion had a significantly higher overall complication rate, longer length of hospital stay, and higher costs than patients who did not receive blood transfusion.

Conclusions: The rate of blood transfusion in autologous breast reconstruction is noticeable (7.0%). Improved awareness of these common risk factors can allow surgeons to identify patients with higher risk to attempt to mitigate complications.

Introduction

Autologous breast reconstruction is associated with a higher long-term satisfaction and more stable esthetic results than implant-based breast reconstruction.[1,2] However, autologous reconstruction techniques commonly involve lengthy procedures susceptible to potentially devastating complications such as flap failure, donor site morbidity, or substantial blood loss necessitating transfusion. To mitigate these risks, identification of potentially modifiable risk factors in autologous breast reconstruction is necessary to reduce adverse patient outcomes, both medically and financially. The rate of blood transfusion has been reported from 1.6% to 95% in autologous breast reconstruction surgery.[4–12] The reported wide range of blood transfusion rate might be related to the complexity of different types of breast reconstruction, institutional (surgeons) criteria for blood transfusion, or surgeon's experience performing these complex procedures. There have been few studies limited to single institution showing the adverse effect of blood transfusion in selected types of autologous breast reconstruction.[5,6,13,14]

Maintaining adequate hemoglobin levels during the intraoperative and postoperative periods is very important. The oxygen content in arterial blood is determined by the amount of hemoglobin, and a decrease in arterial oxygen resulting from anemia is directly associated with flap failure.[15] The volume of perioperative blood loss and subsequent need for blood transfusion has been shown to increase patient morbidity and length of hospital stay as well as cost.[9] In addition, transfusions are not completely benign treatments and are associated with risks including allergic reactions and hemolytic reactions, which can result in coagulopathy and organ dysfunction. Additionally, we need to mention about the risk of transfusion-transmitted infections such as HIV or hepatitis, although the risk is extremely rare.[16]

What is unclear is the relationship between specific patient comorbidities or type of breast reconstruction and the risk of blood loss necessitating transfusion during autologous breast reconstruction. Knowledge of the risk factors associated with blood transfusion might help plastic surgeons minimize allogenic blood transfusions and their associated risks. To the best of our knowledge, there is no large study evaluating the risk factors of blood transfusion considering all types of autologous breast reconstruction; therefore, we intended 1) to evaluate the rate of blood transfusion and 2) to identify independent risk factors of blood transfusion in autologous breast reconstruction using the Nationwide Inpatient Sample (NIS) database.

Materials and methods

Database

The NIS database is the largest available all-payer inpatient health care database in the United States, yielding national estimates of hospital inpatient stays. The NIS database is part of databases and software tools developed for the Healthcare Cost and Utilization Project (HCUP). The NIS database is drawn from all States participating in HCUP, representing more than 97% of the U.S. population. The NIS database includes a nationally represented sample of approximately 20% of U.S. community hospitals excluding rehabilitation and long-term acute care hospitals (unweighted data). The NIS database can be weighed to yield national estimates.[17] Data elements within the NIS database allow determination of all procedures performed during a given hospital admission. In addition, the NIS database comprises discharge information of inpatient hospital stay, including patient characteristics, in-hospital postoperative complications, length of hospital stay, total hospital charges, and observed in-hospital mortality. The NIS database does not have any information of complications occurring after discharge.

Data analysis

We studied discharge data on patients who underwent autologous breast reconstruction surgery from 2012 to 2014. To identify our patient population, we used International Classification of Diseases, ninth revision, Clinical Modification (ICD-9-CM)[18] procedure codes of autologous breast reconstructions including latissimus dorsi myocutaneous flap (LD, 85.71), pedicled transverse rectus abdominis myocutaneous flap (TRAM, 85.72), free transverse rectus abdominis myocutaneous flap (85.73), free deep inferior epigastric artery perforator flap (DIEP, 85.74), free superficial inferior epigastric artery flap (SIEA, 85.75), free gluteal artery perforator flap (GAP, 85.76), and other types of autologous breast reconstruction including non-otherwise specified (85.71 and 85.79). ICD-9 CM codes of blood transfusion were used to detect patients who received blood transfusion.

To identify immediate versus delayed autologous breast reconstruction, patients who had ICD-9-CM procedure codes of mastectomies in combination with autologous breast reconstruction codes were included in the immediate breast reconstruction group. Analyzed preoperative factors were

patient characteristics, patient comorbidities, type of autologous breast reconstruction, timing of reconstruction, history of chemotherapy or radiotherapy, and teaching status of the hospital. The main outcome measures of this study were 1) the overall rate of blood transfusion, and 2) risk factors of blood transfusion in this patient population. Additionally, we compared the perioperative outcomes (complications, mortality, length of hospital stays, and total hospital charges) of patients who received blood transfusion with patients who did not.

Statistical analyses: All statistical analyses for the NIS database were performed using SAS software version 9.4 (SAS Institute, Cary, North Carolina). As the NIS database is a stratified sample of 20% of all the U.S. hospitals, discharge weight was used to create national estimates for all analyses. We used univariate and multivariate regression analyses to identify independent predictors of blood transfusion following autologous breast reconstructive surgery. Factors were statistically significant in univariate analyses or factors that were clinically expected to have an impact on blood transfusion were included in multivariate regression analysis. Statistical significance was set at p-values <0.05.

Results

A total of 55,840 patients were identified who underwent autologous breast reconstruction during this period. Analyzing patient characteristics, the mean age was 52 years old and 11.3% of the patients were older than 65 years old (Table 1). The majority of the patients were Caucasian (71.0%) and the three most common comorbidities were hypertension (26.9%), chronic lung disease (8.9%), and diabetes mellitus (7.8%). The two most common types of autologous breast reconstruction were DIEP (31.6%) and LD flap (31%). Considering the timing of breast reconstruction, the majority of patients underwent delayed (60%) versus immediate (40%) breast reconstruction. In addition, the majority of the operations were performed at teaching hospitals (80%).

The overall rate of blood transfusion was 7.0%. The lowest rate of blood transfusion was reported in LD flap patients (3.3%), whereas the highest blood transfusion rate was found in the GAP flap patients (22.5%) (Table 2). Patients who received blood transfusion had a significantly higher complication rate (29.55% vs. 8.48%; $p < 0.01$), longer mean length of stay (6.6 days vs. 3.6 days; $p < 0.01$), higher mean total hospital charges ($126,278 vs. $76,617; $p < 0.01$), and higher in-hospital mortality rate than those who did not receive blood transfusion (0.51% vs. 0.02%; $p < 0.01$). All of the evaluated postoperative complications were significantly higher in patients who received blood transfusion except rates of fat necrosis and seroma rates, for which there was no significant difference between these two groups (Table 3).

The results of univariate and multivariate regression analyses are shown in Table 4 and Table 5, respectively. Using multivariate regression analysis (Table 5), chronic anemia (adjusted odds ratio [AOR], 5.17; CI: 4.73-5.65; $p < 0.01$), congestive heart failure (AOR, 4.07; CI: 3.08-5.37; $p < 0.01$), free flap (AOR, 2.03; CI: 1.89-2.19; $p < 0.01$), chronic kidney disease (AOR, 1.79; CI: 1.35-2.38; $p < 0.01$), hypertension (AOR, 1.39; CI: 1.29-1.50; $p < 0.01$), chronic lung disease (AOR, 1.23; CI: 1.10-1.37; $p < 0.01$), diabetes mellitus (AOR, 1.21; CI:1.08-1.36; $p < 0.01$), non-teaching hospital (AOR, 1.20; CI:1.10-1.30; $p < 0.01$), and obesity (AOR, 1.12; CI:1.01-1.25; $p < 0.01$) were found to be significant risk factors of blood transfusion. However, there was no association between age, race, liver disease, smoking, prior history of chemotherapy, or reconstruction time (immediate versus delayed) on blood transfusion. In addition, patient with a prior history of radiation had a significantly lower rate blood transfusion (AOR, 0.76).

Table 1 Characteristics of patients who underwent autologous breast reconstruction in the United States during 2012-2014.

Characteristics	Overall
Number	55,840
Age (year)	
Mean	52 ± 10
Median	52
Mode	52
Over 65 (%)	11.3
Race (%)	
White	71.0
Black	13.5
Hispanic	8.2
Asian/Islander	3.1
Native American	0.3
Other	3.9
Comorbidity (%)	
Diabetes mellitus	7.8
Hypertension	26.9
Congestive heart failure	0.6
Chronic lung disease	8.9
Chronic kidney disease	0.7
Liver disease	0.6
Smoker	17.9
Obesity	10.0
Chronic anemia	5.8
Teaching hospitals (%)	80.0
Immediate reconstruction (%)	40.0
Prior chemotherapy (%)	11.7
Prior radiation (%)	16.7

Discussion

Identification of independent risk factors could help minimize the need for perioperative blood transfusions and their associated risks during autologous breast reconstruction. A large-scale patient database comprising those who underwent autologous breast reconstruction was reviewed to determine the following on the rate of perioperative blood transfusions: patient characteristics including comorbidities, type and timing of breast reconstruction, radiation and chemotherapy, as well as teaching status of the hospital. Consistent with prior studies,[2,3,9,10] our data analyses identified a higher overall complication rate (3.5 times

Table 2 Frequency of autologous breast reconstruction type and blood transfusion rate.

Autologous breast reconstruction types	Overall frequency (%)	Blood transfusion (%)
LD flap	17,330 (31.04%)	574 (3.3%)
Pedicled TRAM flap	6490 (11.62%)	625 (9.6%)
Free TRAM flap	8910 (15.96%)	960 (10.8%)
DIEP flap	17.660 (31.63%)	1550 (8.8%)
SIEA flap	385 (0.69%)	40 (10.4%)
GAP flap	354 (0.64%)	80 (22.5%)
Not otherwise specified	4710 (8.43%)	75 (1.6%)

*Latissimus dorsi myocutaneous flap (LD), pedicle transverse rectus abdominis myocutaneous flap (TRAM), Free deep inferior epigastric artery perforator flap (DIEIP), free superficial inferior epigastric artery flap (SIEA), free gluteal artery perforator flap (GAP).

Table 3 Comparison of outcomes in autologous breast reconstruction with and without blood transfusion.

Outcomes	Without transfusion: Number of patients 51,935 (93%)	With transfusion: Number of patients 3905 (7%)	*p*-value
Urinary tract infection	455 (0.88%)	60 (1.54%)	<0.01
Pneumonia	130 (0.25%)	70 (1.79%)	<0.01
Acute respiratory failure	235 (0.45%)	67 (1.79%)	<0.01
Acute kidney injury	275 (0.53%)	95 (2.43%)	<0.01
Venous thromboembolism	35 (0.07%)	25 (0.64%)	<0.01
Myocardial infarction	15 (0.03%)	5 (0.13%)	<0.01
Stroke	20 (0.04%)	10 (0.26%)	<0.01
Wound infections	600 (1.16%)	150 (3.84%)	<0.01
Wound dehiscence	368 (0.71%)	68 (1.76%)	<0.01
Hematoma	1005 (1.94%)	460 (11.78%)	<0.01
Fat necrosis	455 (0.88%)	35 (0.90%)	0.89
Seroma	605 (1.16%)	55 (1.41%)	0.17
Flap failure	524 (1.01%)	120 (3.07%)	<0.01
Overall complication rate	4405 (8.48%)	1155 (29.58%)	<0.01
Length of hospital stay (days)	3.6 (± 2.5)	6.6 (± 8.8)	<0.01
Mean total hospital charges ($)	76,617 (+/-52,462)	126,278 (+/−100,199)	<0.01
In-hospital mortality	10 (0.02%)	20 (0.51%)	<0.01

higher), longer mean length of hospitalization (in average 3 days longer hospital stay), and higher hospital costs in patients who received perioperative blood transfusion than in those who did not. The current study showed the worse outcomes in patients who received blood transfusion; however; it is impossible to state whether blood transfusions are a symptom or a cause of the adverse outcomes in these patients.

The current study showed that the overall rate of blood transfusion in relation to autologous breast reconstruction was 7% and varied rate between reconstruction techniques. Upon review of the literature, there are references to transfusion rates from 1.6% to 95%.[3-12] The reported wide range of blood transfusion rate might relate to the complexity of type of breast reconstruction, institutional/surgeons criteria for blood transfusion, or surgeon's experience performing these complex procedures. Comparing blood transfusion rate based on the flap donor site, patients with an LDF flap had the lowest rate of blood transfusion (3.3%), followed by abdominal-based reconstruction (8.8% in DIEP flap to 10.8% in free TRAM flap) and gluteal-based reconstruction (22.5%). This finding might be related to 1) the complexity and associated morbidity of autologous breast reconstruction type and 2) frequency of the performed reconstruction technique. There are previous large nationwide studies that showed the LD flap was associated with the lowest rate of postoperative complications among the other types of autologous breast reconstruction.[3,19] The highest rate of blood transfusion was associated with the GAP flap (22.5%), and simultaneously, the GAP flap was the least frequently used type of autologous breast reconstruction. The challenging perforator dissection and need for microsurgical expertise may contribute to the reluctant use of the GAP flap by many reconstructive surgeons. However, the ability to perform a single-stage breast reconstruction with buttock tissue when abdominal or thigh tissue is unavailable provides a significant service to the patient desiring an autologous breast reconstruction.[20]

Furthermore, our study demonstrates that free flap-based reconstruction had twice the higher rate of blood transfusion than pedicled-based reconstruction. Similarly, Gart et al.,[3] in a study using The National Surgical Quality Improvement Program (NSQIP) database comparing outcomes of different types of autologous breast reconstruction, showed the free flap breast reconstruction was associated with a significantly higher rate of blood transfusion

Table 4 Univariate regression analysis for blood transfusion following autologous breast reconstructive surgery.

Factors	AOR (95% CI*)	*p*-value
Age group		
<65 years	Reference	Reference
≥65 years	0.93 (0.83-1.03)	0.16
Race	NS*	NS
Comorbidities		
No comorbidities	Reference	Reference
Hypertension	1.56 (1.46-1.67)	<0.01
Chronic lung disease	1.40 (1.27-1.56)	<0.01
Diabetes mellitus	1.54 (1.39-1.72)	<0.01
Congestive heart failure	6.14 (4.81-7.84)	<0.01
Chronic kidney disease	3.26 (2.53-4.21)	<0.01
Liver disease	0.83 (0.53-1.31)	0.42
Obesity	1.43 (1.30-1.58)	<0.01
Chronic anemia	6.12 (5.62-6.66)	<0.01
Smoking	1.02 (0.93-1.10)	0.72
Reconstruction type		
Pedicled flap	Reference	Reference
Free flap	2.01 (1.87-2.16)	<0.01
Reconstruction timing		
Immediate	Reference	Reference
Delayed	1.0 (0.93-1.07)	0.94
History of chemotherapy		
No	Reference	Reference
Yes	0.97 (0.88-1.08)	0.59
History of radiotherapy		
No	Reference	Reference
Yes	0.77 (0.70-0.85)	0.91
Teaching status of hospitals		
Non-teaching hospital	Reference	Reference
Teaching hospital	0.97 (0.90-1.05)	0.50

* AOR, Adjusted Odds Ratio; CI: Confidence Interval; NS: Not Significant.

Table 5 Multivariate regression analysis for blood transfusion following autologous breast reconstructive surgery.

Factors	AOR (95% CI*)	*p*-value
Age group		
<65 years	Reference	Reference
≥65 years	0.92 (0.82-1.03)	0.17
Comorbidities		
No comorbidities	Reference	Reference
Hypertension	1.39 (1.29-1.50)	<0.01
Chronic lung disease	1.23 (1.10-1.37)	<0.01
Diabetes mellitus	1.21 (1.08-1.36)	<0.01
Congestive heart failure	4.07 (3.08-5.37)	<0.01
Chronic kidney disease	1.79 (1.35-2.38)	<0.01
Liver disease	0.71 (0.44-1.14)	0.15
Obesity	1.12 (1.01-1.25)	0.03
Chronic anemia	5.17 (4.73-5.65)	<0.01
Smoking	1.06 (0.97-1.16)	0.18
Reconstruction type		
Pedicled flap	Reference	Reference
Free flap	2.03 (1.89-2.19)	<0.01
Reconstruction timing		
Immediate	Reference	Reference
Delayed	0.95 (0.88-1.02)	0.13
History of chemotherapy		
No	Reference	Reference
Yes	0.96 (0.85-1.08)	0.53
History of radiotherapy		
No	Reference	Reference
Yes	0.76 (0.68-0.84)	<0.01
Teaching status of hospitals		
Teaching hospital	Reference	Reference
Non-teaching hospital	1.20 (1.10-1.30)	<0.01

* AOR, Adjusted Odds Ratio; CI: Confidence Interval; NS: Not Significant.

than pedicled flaps (free flap: 7.1% vs. LD flap: 1.6% and pedicled TRAM flap: 1.9%). Plastic surgeons should consider this when selecting the appropriate type of breast reconstruction especially in patients with additional risk factor(s) of blood transfusion.

With regard to patient comorbidities, chronic anemia (AOR, 5.17) and CHF (AOR, 4.07) were two major risk factors of perioperative blood transfusion. Chronic or preoperative anemia has consistently been shown in the literature to be a strong predictor of perioperative transfusion requirement with autologous breast reconstruction.[5,11] Therefore, identifying anemic patients by obtaining preoperative complete blood count (CBC) is crucial, and correction of anemia before breast reconstruction should be considered with the hope of reducing blood transfusion in this patient population. Other comorbidities that were a minor risk factor of blood transfusion included chronic kidney disease (AOR, 1.79), hypertension (AOR, 1.39), chronic lung disease (AOR, 1,23), diabetes mellitus (AOR, 1.21), and obesity (AOR, 1.12). With these data, preoperative evaluations for autologous breast reconstruction should include discussions of patient comorbidities and their associated risks of perioperative blood loss necessitating transfusion. Furthermore, recognition of these risk factors should prompt plastic surgeons to modify their approach to autologous breast reconstruction. When appropriate, surgeons should coordinate care of patients who have strong predictors of increased intraoperative blood loss. Any patient comorbidities that are linked to increase transfusion requirements should undergo medical optimization before surgery as well as perioperatively.

In addition, the current study demonstrates that there was no statistically significant correlation between age, race, smoking, or history of prior chemotherapy and rate of perioperative blood transfusion. However, our study showed that patients with a prior history of radiotherapy had a lower rate blood transfusion. Interestingly, Lymperopoulous et al.[5], in a study evaluating blood loss and transfusion rates in 131 patients who underwent DIEP flap breast reconstruction, found no correlation between age, chemotherapy, and/or radiotherapy or tamoxifen and blood loss. However, they showed that longer operative time, the presence of complication, and the greater weight of tissue removed from the abdomen had significant correlation with blood loss. Further, our study showed no correlation between reconstruction timing (immediate versus delayed)

and blood transfusion. Consistent with our study, Ting et al.[11] showed that immediate reconstruction is not a predictor of blood transfusion in DIEP flap breast reconstruction. However, they showed anemia and bilateral breast reconstruction as two predictor risk factors of blood transfusion.

Furthermore, breast reconstruction that occurred at a teaching hospital failed to demonstrate higher rates of blood transfusion. Consistent with the current study, Masoomi et al.[21], in a study using the NIS database, showed that despite more complex free flap breast reconstructions being performed in teaching hospitals, there was no statistically significant difference in perioperative outcomes between teaching and nonteaching hospitals.

The limitations of this study are similar to those of other retrospective studies using a large database. For example, the data from this database are collected by trained coders; however, the accuracy of the blood transfusion rate might be overestimated or underestimated based on the accuracy of reporting and/or documentation. The NIS database is an in-patient database without outpatient follow-up; therefore, we are unable to capture readmissions and post-discharge complications including blood transfusions. Moreover, we were unable to identify 1) the indications for blood transfusions that may vary by institution or surgeon, 2) units of transfused blood, and 3) intraoperative versus postoperative blood transfusion in these patients. For example, there may be reconstructive surgeons who do not follow evidence-based guidelines on transfusion or have specific indications for blood transfusion. In addition, we were unable to identify unilateral versus bilateral reconstructions, which may likely have an effect on blood transfusion rate.[11] Although we were unable to evaluate the effect of fresh versus old red blood cell transfusion, Lee et al.[6], in a retrospective study evaluating the effect of age of blood transfused in 261 patients who underwent free muscle-sparing TRAM flap, showed that patients who received old blood (stored >14 days) compared with those who received fresh blood (stored $=<14$ days) or no transfusion had a higher incidence of complications (44.1% vs. 20% or 12.8%; $p < 0.05$). Therefore, the availability of fresh blood might be considered while preparing these patients especially with a higher risk for blood transfusion. Lastly, the surgical techniques involved with each flap type were not discussed, and we, therefore, cannot comment on the degree of complexity of each flap in relation to transfusion requirement. Despite the mentioned limitations, to the best of our knowledge, this is the largest study concentrating on the risk factors of blood transfusion in autologous breast reconstruction using a nationwide database.

In conclusion, the rate of blood transfusion in autologous breast reconstruction is not insignificant. Increased rates of blood transfusion are associated with higher complication rates related to surgery. The major independent risk factors that were identified include chronic anemia, congestive heart failure, and free flap-based reconstruction. Improved awareness of these common risk factors can allow surgeons to identify patients with higher risk to attempt to mitigate complications. Future prospective studies will require to evaluate the risk factor of blood transfusion in autologous breast reconstruction in detail with consideration of the limitations of this study.

Conflict of interest

None.

Funding

None of the authors have any financial disclosures.

References

1. Hu ES, Pusic AL, Waljee JF, Kuhn L, Hawley ST, Wilkins E, et al. Patient-reported aesthetic satisfaction with breast reconstruction during the long-term survivorship period. *Plast Reconstr Surg* 2009;**124**:1–8.
2. Yueh JH, Slavin SA, Adesiyun T, Nyame TT, Gautam S, Morris DJ, et al. Patient satisfaction in postmastectomy breast reconstruction: a comparative evaluation of DIEP, TRAM, latissimus flap, and implant techniques. *Plast Reconstr Surg* 2010;**125**:1585–95.
3. Gart MS, Smetona JT, Hanwright PJ, Fine NA, Bethke KP, Khan SA, et al. Autologous options for postmastectomy breast reconstruction: a comparison of outcomes based on the American college of surgeons national surgical quality improvement program. *J Am Coll Surg* 2013;**216**(2):229–38.
4. Tzilinis A, Lofman AM, Tzarnas CD. Transfusion requirements for TRAM flap postmastectomy breast reconstruction. *Ann Plast Surg* 2003;**50**:623–7.
5. Lymperopoulos NS, Sofos S, Constantinides J, Koshy O, Graham K. Blood loss and transfusion rates in DIEP flap breast reconstruction. Introducing a new predictor. *J. Plast. Reconstr. Aesthet. Surg.* 2013;**66**:1659–64.
6. Lee H-K, Kim D-H, Jin U-S, Jeon Y-T, Hwang J-W, Park H-P. Effect of perioperative transfusion of old red blood cells on postoperative complications after free muscle sparing transverse rectus abdominis myocutaneous flap surgery for breast reconstruction. *Microsurgery* 2014;**34**:434–8.
7. Elliott LF, Eskenazi L, Beegle PH Jr, Podres PE, Drazan L. Immediate TRAM flap breast reconstruction: 128 consecutive cases. *Reconstr Surg* 1993;**92**:217–27.
8. Hassan S, Ng M, Warren G, Shetty S, Naasan A. Indications for blood transfusion following breast reconstruction. *Eur J Plast Surg* 2012;**35**:855.
9. Rinker BD, Bowling JT, Vasconez HC. Blood transfusion and risk of metastatic disease or recurrence in patients undergoing immediate TRAM flap breast reconstruction: a clinical study and meta-analysis. *Plast Reconstr Surg* 2007;**119**(7):2001–7.
10. Lennox PA, Clugston PA, Beasley ME, Bostwick J. Autologous blood transfusion in TRAM breast reconstruction: is it necessary? *Ann Plast Surg* 2004;**53**:532–5.
11. Ting J, Rozen WM, Le Roux CM, Ashton MW, Garcia-Tutor E. Predictors of blood transfusion in deep inferior epigastric artery perforator flap breast reconstruction. *J Reconstr Microsurg* 2011;**27**(4):233–8.
12. Holley DT, Toursarkissian B, Vásconez HC, Wells MD, Kenady DE, Sloan DA, et al. The ramifications of immediate reconstruction in the management of breast cancer. *Am Surg* 1995;**61**(1):60–5.
13. Fischer JP, Nelson JA, Au A, Tuggle CT 3rd, Serletti JM, Wu LC. Complications and morbidity following breast reconstruction – a Review of 16,063 cases from 2005 – 2010 NSQIP datasets. *J Plast Surg Hand Surg* 2014;**48**:104–14.
14. Kim BD, Ver Halen JP, Mlodinow AS, Kim JY. Intraoperative transfusion of packed red blood cells in microvascular free tissue transfer patients: assessment of 30-Day morbidity using the NSQIP dataset. *J Reconstr Microsurg* 2014;**30**:103–14.
15. Hill JB, Patel A, Del Corral GA, Sexton KW, Ehrenfeld JM, Guil-

lamondegui OD, Shack RB. Preoperative anemia predicts thrombosis and free flap failure in microvascular reconstruction. *Ann Plast Surg* 2012;**69**:364–7.
16. Savage WJ. Transfusion reactions. *Hematol. Oncol. Clin. North Am.* 2016;**30**:619–34.
17. https://www.hcup-us.ahrq.gov/nisoverview.jsp. Reviewed on 4/20/2019.
18. http://www.cdc.gov/nchs/icd/icd9.htm. Reviewed on 4/20/2019.
19. Masoomi H, Wirth GA, Paydar KZ, Salibian AA, Mowlds DS, Evans GR. Comparison of perioperative outcomes of autologous breast reconstruction surgeries. *J Plast Reconstr Aesthet Surg* Oct 2015;**68**(10):1473–6.
20. Hunter C1, Moody L, Luan A, Nazerali R, Lee GK. Superior gluteal artery perforator flap: the beauty of the buttock. *Ann Plast Surg* 2016;**76**(Suppl 3):S191–5.
21. Masoomi H, Wirth GA, Paydar KZ, Richland BK, Evans GR. Perioperative outcomes of autologous breast reconstruction surgery in teaching versus nonteaching hospitals. *Plast Reconstr Surg* 2014;**134**(4) 514e–520e.