Trauma Surgery & Acute Care Open

Transfusion rates in emergency general surgery: high but modifiable

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► Additional material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/tsaco-2019-000371).

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The 14th Annual Academic Surgical Congress in Houston, Texas on February 5, 2019.

Received 25 August 2019
Revised 13 December 2019
Accepted 18 December 2019

To cite: Medvecz A, Bernard A, Hamilton C, *et al*. *Trauma Surg Acute Care Open* 2020;**5**:e000371.

ABSTRACT

Background Transfusion of red blood cells (RBC) increases morbidity and mortality, and emergency general surgery (EGS) cases have increased risk for transfusion and complication given case complexity and patient acuity. Transfusion reduction strategies and blood-conservation technology have been developed to decrease transfusions. This study explores whether transfusion rates in EGS have decreased as these new strategies have been implemented.

Methods This is a retrospective review of the American College of Surgeons' National Surgical Quality Improvement Program (ACS NSQIP) data from three academic medical centers. Operations performed by general surgeons on adults (aged ≥18 years) were selected. Data were analyzed from two periods: 2011–2013 and 2014–2016. Cases were grouped by the first four digits of the primary procedure Current Procedural Terminology code. Transfusion was defined as any RBC transfusion during or within 72 hours following the operation. Composite morbidity was defined as any NSQIP complication within 30 days following the operation.

Results Overall general surgery transfusion rates decreased from 6.4% to 4.8% from period 1 to period 2 (emergent: 16.6%–11.5%; non-emergent 4.9%–3.7%; Fisher's exact p values <0.001). Among patients transfused, the number of units received decreased slightly (median 2 U (IQR 2–3) to median 2 U (IQR 1–3), Mann-Whitney U test p=0.005). Morbidity decreased (overall: 13.8%–12.3%, p=0.001; emergent: 26.3%–20.6%, p<0.001) while mortality did not change.

Discussion Rates of RBC transfusion decreased in both emergent and non-emergent cases. Efforts to reduce transfusion may have been successful in the EGS population. Morbidity improved over the time periods while mortality was unchanged.

Level of Evidence Level III.

INTRODUCTION

Blood transfusion can be a life-saving therapy for patients experiencing trauma, undergoing complex operations or experiencing disease processes which leave them chronically anemic. Transfusion has become a common therapy with 6.1 million units of whole/red blood cell (RBC) blood transfused in the USA in 2013.[1] However, while blood transfusion can have a life-sustaining effect, it comes with intrinsic risks that can lead to increased morbidity and mortality. These complications can be described in the context of transfusion-related immunomodulation (TRIM), leading to stimulated immunity and alloimmunization of the host or, conversely, immune tolerance.[2] For surgical and critically ill patients, TRIM can be associated with increased risk of bacterial infectious complications,[3 4] transfusion-related acute lung injury[5] and increased mortality.[2 6] For patients undergoing emergent general surgery procedures, the risk of transfusion-related complications adds to the inherent risk of urgent and emergent operations.[7 8]

Many efforts have been undertaken over the past 15 years seeking to reduce transfusion-related complications as well as prevent unnecessary transfusion and depletion of a limited resource. An initial target was the transfusion trigger which historically was based on weak evidence and physician experience, likely leading to a higher than necessary rate of blood transfusions in US hospitals.[9] The authors of this study (AB and DD), as well as others, instituted programs at their institution to reduce the transfusion trigger through provider feedback and education.[10–13] Other strategies included the use of new blood-conserving technologies[14 15] and campaigns to reduce iatrogenic blood loss.[16 17] At two of our institutions (hospitals A and B), there have been specific efforts to implement these strategies in the surgical population.

National trends in blood transfusions in the USA demonstrated a rise in the 1990s and early 2000s but have since demonstrated a trend toward fewer in-hospital transfusions.[18 19] These national trends may reflect many of the efforts targeted to reduce patient complications, improve outcomes and reduce cost by reducing blood transfusions. However, there has been a paucity of literature demonstrating a reduction of transfusions in surgical patients, particularly in the emergency general surgery patient population for whom significant morbidity and mortality already exist because of the nature of the operations.[7] The authors have witnessed and participated in several practices targeted within their own institutions to reduce transfusions. The goal of the study is to demonstrate that there has been a reduction in the blood transfusion among patients undergoing emergency general surgery procedures. We hypothesize that there has been a reduction in transfusions even in emergency general surgery where operative and patient risk is elevated.

METHODS

This study is a retrospective review of the American College of Surgeons' National Surgical Quality Improvement Program (ACS NSQIP) data from

Table 1 Select patient and operative characteristics by site

Variable	Hospital A	Hospital B	Hospital C	All patients	P value
No. of patients	6719	8892	7829	23 440	
Emergency case, %	17.7%	13.2%	9.3%	13.2%	<0.001
Outpatient surgery, %	35.7%	32.7%	20.1%	29.4%	<0.001
Mean primary procedure work relative value units (RVUs) (SD)	17.3 (8.5)	15.2 (7.6)	16.1 (8.5)	16.2 (8.2)	<0.001
Patient's age≤40 years	24.5%	22.5%	17.2%	21.3%	<0.001
Patient's age >70 years	13.3%	14.3%	21.5%	16.4%	
Male, %	43.0%	43.7%	39.3%	42.0%	<0.001
Minority race, %	8.6%	13.0%	23.4%	15.2%	<0.001
ASA class III	51.1%	52.7%	42.7%	48.9%	<0.001
ASA class IV–V	6.0%	4.4%	4.3%	4.8%	
HCT >38%	68.2%	67.6%	69.2%	68.3%	<0.001
HCT 35.1%–38%	12.9%	14.6%	15.0%	14.2%	
HCT≤35%	18.9%	17.8%	15.8%	17.5%	

ASA, American Society of Anesthesiologists; HCT, hematocrit.

three academic medical centers that are also level I trauma centers: University of Kentucky, Vanderbilt University Medical Center and Yale University. Data from operations performed by general surgeons on adults (aged ≥18 years) were selected from each site's local NSQIP databases and aggregated. Data were analyzed from two periods: period 1 (1 January 2011 to 31 December 2013) and period 2 (1 January 2014 to 31 December 2016).

Procedures were grouped by the first four digits of the primary procedure Current Procedural Terminology (CPT) code. Procedure groups with fewer than 100 cases and fewer than 10 total transfusions were combined into an 'other' group. This process resulted in 40 procedure groups. Cases were identified as 'emergent' or 'non-emergent' based on NSQIP criteria. Transfusion in the database is defined as any transfusion of packed RBCs during or within 72 hours following the operation. Total units transfused were also analyzed.

A patient was classified as having composite morbidity if they had any of the following complications within 30 days of the operation which was not present prior to the operation: surgical site infection (SSI) (superficial, deep or organ/space), surgical wound dehiscence, treated pulmonary embolism or deep vein thrombosis, sepsis or septic shock, urinary tract infection, progressive renal insufficiency or renal failure, acute myocardial infarction or cardiac arrest requiring resuscitation, stroke with persistent deficit, pneumonia, unplanned intubation or mechanical ventilation for >48 hours.

Transfusion rates were compared between groups using χ^2 or Fisher's exact tests. The Mann-Whitney U test was used to compare the number of units that were transfused in the two time periods. Forward multivariable logistic regression was used to compare the transfusion rates in the late versus early time periods considering all NSQIP variables (p for entry <0.05, p for exit <0.10) for adjustment. Statistical analyses were performed using SPSS V.23 (IBM, Armonk, New York, USA).

RESULTS

From 2011 to 2016, 23 440 general surgery cases were performed at the three medical centers (table 1). Between period 1 and 2, overall transfusion rates of general surgery cases decreased from 6.4% to 4.8% (table 2, Fisher's exact p<0.001). Transfusion rates decreased in 32 of the 40 procedure groups (online supplementary appendix 1), and 6 of the procedure groups had transfusion reductions that were significant (p<0.05): partial colectomy (4414X and 4416X), partial hepatectomy/left hepatectomy (4712X), right hepatectomy/liver transplant (4713X), total pancreatectomy and Whipple procedure (4815X) and repair of recurrent incisional or ventral hernia (4956X). Three groups (breast lesion excision, thyroid lobectomy and parathyroidectomy) had no transfusions in both periods; five groups (laparoscopic jejunostomy/colostomy, laparoscopic appendectomy, proctectomy/pelvic exenteration, inguinal hernia repair

Table 2 Transfusion rates by emergent status, period and site

		All cases		Emergent		Non-emergent	
		2011–13	2014–16	2011–13	2014–16	2011–13	2014–16
All sites	n	12 268	11 172	1596	1502	10 672	9670
	Transfused %	6.4%	4.8%***	16.6%	11.5%***	4.9%	3.7%***
Hospital A	n	3579	3140	641	548	2938	2592
	Transfused %	7.5%	5.2%***	17.5%	13.7%	5.3%	3.4%***
Hospital B	n	4450	4442	520	658	3930	3784
	Transfused %	7.9%	4.3%***	21.0%	9.4%***	6.2%	3.4%***
Hospital C	n	4239	3590	435	296	3804	3294
	Transfused %	4.0%	5.0%*	10.1%	11.8%	3.3%	4.4%*

*P<0.05; ***p<0.001 (change in period 2 was statistically significant).

and total thyroidectomy) had increased transfusion, none of which was significant.

During the same periods in all cases, major morbidity decreased (13.8% to 12.3%, p=0.001), while 30-day mortality (1.4% to 1.5%), unplanned readmission (8.5% to 8.5%) and unplanned return to OR (3.8% to 3.6%) did not change significantly. In emergent cases only, the changes in other outcomes were similar, with significant reductions in major morbidity (26.3% to 20.6%, p<0.001) and without significant changes in 30-day mortality (6.6% to 6.7%), unplanned readmission (10.3% to 9.2%) and unplanned return to the operating room (6.7% to 6.1%). In emergent cases, all infectious morbidities were reduced including: urinary tract infection (not present at time of surgery (PATOS), 2.3% vs 0.9%, p=0.002); SSI (not PATOS, 9.0% vs 4.7%, p<0.001); sepsis/shock (not PATOS, 7.1% vs 4.3%, p<0.001) and pneumonia (not PATOS, 6.0% vs 4.5%, p=0.037). Unplanned intubation or mechanical ventilation >48 hours was also reduced (10.7% vs 8.4%, p=0.019). Renal failure/insufficiency, treated venous thromboembolic events, cardiac arrest or infarct and stroke were not significantly decreased.

Emergent cases had a significant reduction in the proportion of cases receiving transfusion (16.6% to 11.5%, p<0.001) (table 2). Hospital B experienced significant reduction in emergent cases transfused (−11.6%, p<0.001), while hospital C had an insignificant increase in the proportion of emergent cases transfused. Hospital A had a reduction in transfusion of emergent cases but this decrease was insignificant. Hospitals A and B also had reduction in the proportion of non-emergent cases that were transfused (−1.9% and −2.8%, p<0.001, respectively).

When stratifying by preoperative hematocrit (HCT), patients with preoperative anemia and HCT <35% had a significant decrease in the proportion of cases transfused (22.6% to 18.0%, p<0.001). (table 3) Patients with preoperative HCT that were 35–38 and above 38 also had significant reduction in the proportion of cases receiving a blood transfusion. Among the patients who received a transfusion, the median number of units transfused remained constant yet the lower quartile for the second period decreased significantly (median 2 U (IQR 2–3) to median 2 U (IQR 1–3), Mann-Whitney U test p=0.005) (figure 1).

In all general surgery cases, multivariable logistic regression to determine the likelihood of a blood transfusion in period 2 compared with period 1 yielded a 47% reduction in the odds of transfusion when controlling for patient and operative risks (OR 0.53, 95% CI 0.46 to 0.61, p<0.001). Compared with hospital C, adjusted transfusion risk was similar at hospital A (OR 0.93, 95% CI 0.77 to 1.14, p=0.487) and higher at hospital B (1.24, 95% CI 1.04 to 1.48, p=0.014). Adjustment variables included 12 patient risk factors (HCT, American Society of Anesthesiologists (ASA) class, preoperative transfusion, SIRS/sepsis/shock, bilirubin >1.0 mg/dL, serum albumin, age decade, partial thromboplastin time >35 s, platelet count <150 000/mm³, platelet count >400 000/mm³, dyspnea, functional status, bleeding disorder (including unknown discontinuance of blood thinners) and creatinine >1.2 mg/dL) and seven operative risk factors (procedure group, first team secondary work RVUs, inpatient surgery, operative duration, second team work RVUs, primary procedure work RVUs and wound class).

In the emergent case population only, the risk-adjusted transfusion reduction across all sites in period 2 was approximately 41% (OR 0.59, 95% CI 0.45 to 0.78, p<0.001). Site

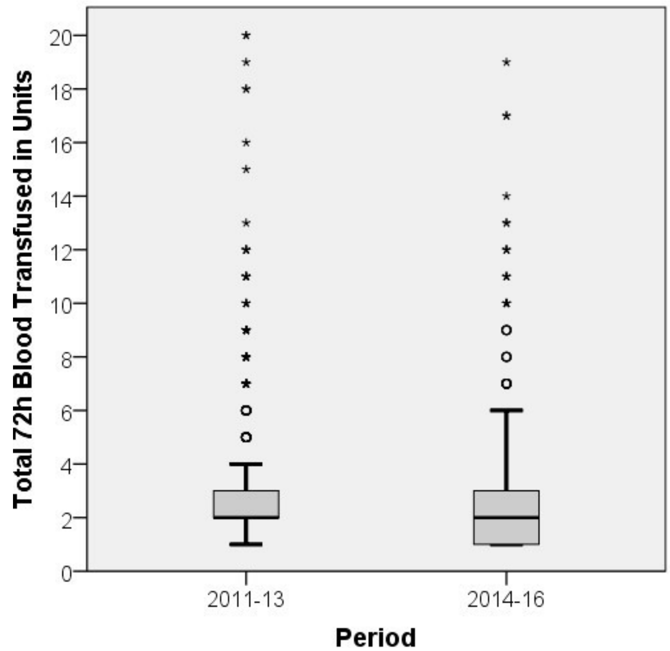

Figure 1 In patients who received blood transfusions, there was a modest decrease in number of units transfused with the 25th percentile decreasing from 2 units to 1 unit (Mann-Whitney U test p=0.005). At one institution, there was an educational campaign aimed at reducing the minimum transfusion from 2 units to 1 unit with the slogan, 'Why give two when one will do?'

Table 3 Transfusion rates by preoperative HCT level, period and site

		HCT >38% or unknown†		HCT 35.1%–38%		HCT ≤35%	
Period		**2011–13**	**2014–16**	**2011–13**	**2014–16**	**2011–13**	**2014–16**
All sites	n	8370	7634	1823	1517	2075	2021
	Transfused %	2.5%	1.4%***	6.3%	3.9%**	22.6%	18.0%***
Hospital A	n	2438	2144	464	402	677	594
	Transfused %	2.8%	1.6%**	6.7%	4.0%	24.8%	18.7%**
Hospital B	n	2937	3071	717	580	796	791
	Transfused %	3.3%	1.3%***	8.1%	3.8%**	24.9%	16.1%***
Hospital C	n	2995	2419	642	535	602	636
	Transfused %	1.4%	1.4%	3.9%	4.3%	17.1%	19.2%

**p<0.01; ***p<0.001 (change in period 2 was significant).
†13% of operations had unrecorded HCT with a disproportionate number of elective outpatient operations. These were classified as low transfusion risk, HCT >38%.
HCT, hematocrit.

B had significantly higher risk of transfusion compared with A (OR 1.89, 95% CI 1.30 to 2.74, p=0.001) while site C did not have significantly higher transfusion risk compared with A (OR 1.31, 95% CI 0.86 to 1.98, p=0.209). Adjustment variables included by order of entry into the regression model: ASA class, HCT, primary procedure work RVUs, preoperative transfusion, secondary procedure work RVUs, preoperative SIRS/sepsis/shock, age, albumin, procedure group (primary procedure work RVUs fell out), bilirubin >1.0 mg/dL and bleeding disorder (including blood thinners). The c-index of the risk model was 0.92 indicating excellent discrimination of transfusion risk.

DISCUSSION

Patients undergoing general surgery operations from 2014 to 2016 were less likely to receive a blood transfusion compared with patients undergoing operations from 2011 to 2013. This reduction was demonstrated in two of the three hospitals that were included in the study, and both institutions have had specific efforts designed to reduce the need for blood transfusion in the medical and surgical populations. One of the hospitals implemented a program within the last 10 years designed to reduce the transfusion threshold throughout the medical system.[10] The program involved the establishment of a 70 g/L hemoglobin transfusion threshold, education of providers and hospital staff and review and feedback of transfusion orders outside the accepted threshold. Over the four study years 2009–2012, RBC transfusions trended down despite discharges and case-mix index trending up, suggesting that the intervention may have been instrumental in reducing the transfusions within the institutions. The time periods in our study, 2011–2013 and 2014–2016, suggest that the impact of the intervention continued beyond the initial study period. Phlebotomy has been identified as a cause of anemia in hospitalized patients,[16 20] so another hospital in this study group implemented a Choosing Wisely campaign designed to reduce the blood sampling.[21] The effort, implemented within the entire medical center, reflects a system-wide change that can have an impact on the transfusion practices in surgery.

We identified a reduction in blood transfusions in emergent cases. Cases in emergency general surgery have been associated with significant morbidity and mortality.[7 8] Emergent cases are often associated with underlying physiological abnormalities or comorbid disease that can complicate the patient's course. The pathophysiology of sepsis and other comorbidities could portend greater blood loss and hemodynamic instability, prompting a lower threshold for transfusion of blood products, reflected in the high mean transfusion rate of 16.6% in the period 1 (single center range 10.1%–21.0%). However, our data suggests that even in these cases of medically complex patients where bleeding is more likely, blood transfusion practice can be modified as the proportion of patients being transfused decreased during period 2, and one center decreasing its transfusion rate in emergent cases by over 10%. Among the factors that may contribute to this decrease are a recognition of the immunomodulation and increased risk for post-transfusion infections or complications, especially in critically ill patients already at risk for morbidities. In our study, transfusion reductions were concomitant with a reduction in major morbidity, but no change in mortality, readmission or unplanned return to the operating room.

Six procedure groups had significant decreases in the proportion of patients given a perioperative transfusion. Recent advances and increased adoption of intraoperative blood salvage and coagulation methods may account for some of the transfusion reduction in patients undergoing hepatectomy or pancreatectomy. Blood loss for partial colectomy in both the emergent and non-emergent setting may have lessened by the institution of Enhanced Recovery After Surgery pathways and SSI reduction bundles that promote better tissue oxygenation and warmth as well as the advance of laparoscopy and robotic surgery which may have led also to decreased operative blood loss. Advances in surgery for recurrent ventral hernia repair with minimally invasive and component-separation techniques may have contributed to its small but significant decrease in transfusion rate.

Another change that may account for the decreased transfusion rate is surgeon comfort with operating on patients with anemia. Our data showed reductions in transfusion in all three centers for the patient group with HCT≤35%. Guidelines from the Eastern Association for the Surgery of Trauma and the Society of Critical Care Medicine recommend more restrictive transfusion practices in many critical care scenarios due to the increased risk for transfusion complications in critically ill patients.[22] The guidelines further discuss using an individual assessment of the clinical status of the patient prior to deciding to transfuse and not merely relying on a hemoglobin trigger.

For those patients who do ultimately require a transfusion, the median number of transfused units was 2 in both period 1 and period 2. However, the bottom quartile of those receiving a transfusion decreased from 2 units in period 1 to 1 unit in period 2. The traditional mantra in surgery has been 'give 2 units' if the patient is meeting transfusion triggers. However, numerous studies and guidelines have been released suggesting a more restrictive transfusion practice that involves transfusing one unit and then checking for appropriate response with a hemoglobin level along with reassessment of the patient's clinical status prior to the decision to transfuse a second unit of blood.[2 22] Institutions have included this strategy in their education and policy change efforts to reduce the number of blood transfusions.[11] Our data suggest that these strategies may be effective in a broader context and may have become pervasive within general surgery practice.

The major limitation of this study is that there is no specific intervention that occurred between the 2011–2013 and 2014–2016 study periods. There has been a national trend for reduction in blood transfusion in hospitalized patients.[18 19] However, we have demonstrated cumulative efforts for blood transfusion reduction has been extended to the general surgery population and that emergent cases do not benefit from liberal transfusion. The reduction in the proportion of patients includes patients undergoing invasive procedures at risk for significant bleeding, and yet our overall practice has been successful in reducing blood transfusion. The study is also limited to physiological data and indications for transfusion available. Prospective studies will be required to shed light on this more granular data.

CONCLUSION

We have demonstrated a decrease in blood transfusion in the emergency general surgery population of three large academic medical centers, reflecting an overall culture change regarding transfusion. Specific efforts, including cell-salvage technology, improved transfusion guidelines and less dependence on laboratory values may have a role within those institutions to account for the reduction in transfusions. Additionally, even medically complex patients requiring emergent operative management may not require transfusion. Further research into blood conservation strategies and systems-based practice may yield additional reductions to the need for blood transfusions among surgical patients.

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Contributors The study concept and design were developed by AB and DD. All authors were responsible for data collection and interpretation. Statistical analysis was performed by DD. AM prepared the manuscript with AB, CH, KS, OG and DD providing critical review.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study was reviewed and approved by the Institutional Review Board of the University of Kentucky, Vanderbilt University Medical Center and Yale University.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. The data are not available for further access.

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