

Overuse of Hematocrit Testing After Elective General Surgery at a Veterans Affairs Medical Center

Anthony Vigil, MD^{a,b}; Taylor Parnall, MD^c; Clifford Qualls, PhD^{a,b}; Robert Glew, PhD^b; Robin Osofsky, MD^d; Micah Guess, RN^a; Lauren Mercer, MD^b

Objective: To evaluate the clinical usefulness and costs of routine postoperative hematocrit testing after elective general surgery.

Methods: We reviewed charts of all patients who had elective general surgery at New Mexico Veterans Affairs Health Care System, Albuquerque hospital from 2011 through 2014. Demographic data and patient characteristics (eg, comorbidities, smoking/drinking history), estimated blood loss (EBL), pre- and postoperative hematocrit levels, and signs and symptoms of anemia were compared in patients who did or did not receive a blood transfusion within 72 hours of the operation.

Results: Of 1531 patients who had an elective general surgery between 2011 and 2014, ≥ 1 postoperative hematocrit levels were measured in 288 individuals. There were 1312 postoperative hematocrit measurements before discharge (mean, 8.7; range, 1–44). There were 12 transfusions (0.8%)

for patients without moderate to severe pre-existing anemia (hematocrit $< 30\%$). Five of 12 transfused patients received intraoperative transfusions and 7 patients were transfused within 72 hours postoperation. No patients were transfused preoperatively. Of 12 patients receiving transfusion, 11 had EBL > 199 mL and/or signs of anemia. Risk factors for postoperative transfusion included lower preoperative hematocrit, increased EBL, and having either abdominoperineal resection or a total proctocolectomy.

Conclusions: Routine postoperative hematocrit measurements after elective general surgery at US Department of Veterans Affairs medical centers are of negligible clinical value and should be reconsidered. Clinical judgment, laboratory-documented pre-existing anemia, a high-risk operation, or symptoms of anemia should prompt monitoring of patient postoperative hematocrit testing. This strategy could have eliminated 206 initial hematocrit checks over the 4 years of the study.

Author affiliations can be found at the end of this article.

Correspondence: Anthony Vigil (anthony.vigil@va.gov)

Fed Pract. 2024;41(7).
Published online June 12.
doi:10.12788/fp.0479

It is common practice to routinely measure postoperative hematocrit levels at US Department of Veterans Affairs (VA) hospitals for a wide range of elective general surgeries. While hematocrit measurement is a low-cost test, the high frequency with which these tests are performed may drastically increase overall costs.

Numerous studies have suggested that physicians overuse laboratory testing.^{1–10} Kohli and colleagues recommended that the routine practice of obtaining postoperative hematocrit tests following elective gynecologic surgery be abandoned.¹ A similar recommendation was made by Olus and colleagues after studying uneventful, unplanned cesarean sections and by Wu and colleagues after investigating routine laboratory tests post total hip arthroplasty.^{2,3}

To our knowledge, a study assessing routine postoperative hematocrit testing in elective general surgery has not yet been conducted. Many laboratory tests ordered in the perioperative period are not indicated, including complete blood count (CBC), electrolytes, and coagulation studies.⁴ Based on the results of these studies, we expected that the routine measurement of postoperative hematocrit levels after elective general surgeries at VA medical centers would not be

cost effective. A PubMed search for articles published from 1990 to 2023 using the search terms “hematocrit,” “hemoglobin,” “general,” “surgery,” “routine,” and “cost” or “cost-effectiveness,” suggests that the clinical usefulness of postoperative hematocrit testing has not been well studied in the general surgery setting. The purpose of this study was to determine the clinical utility and associated cost of measuring routine postoperative hematocrit levels in order to generate a guide as to when the practice is warranted following common elective general surgery.

Although gynecologic textbooks may describe recommendations of routine hematocrit checking after elective gynecologic operations, one has difficulty finding the same recommendations in general surgery textbooks.¹ However, it is common practice for surgical residents and attending surgeons to routinely order hematocrit on postoperative day-1 to ensure that the operation did not result in unsuspected anemia that then would need treatment (either with fluids or a blood transfusion). Many other surgeons rely on clinical factors such as tachycardia, oliguria, or hypotension to trigger a hematocrit (and other laboratory) tests. Our hypothesis is that the latter group has chosen the most cost-effective and prudent

TABLE 1 Preoperative Inpatient Characteristics

Variable	Transfusion group (n = 12)	Nontransfusion group (n = 418)	P value
Age, mean (SD), y	67.5 (8.7)	62.5 (11.2)	.07
Sex, No (%)			.99
Male	11 (92)	374 (89)	
Female	1 (8)	44 (11)	
Body mass index, mean (SD)	27.4 (5.6)	28.1 (5.6)	.68
Race and ethnicity, No. (%) ^a			.54
Black	1 (8)	11 (3)	
Hispanic/Latino	3 (25)	95 (23)	
Native American	0 (0)	9 (2)	
White	6 (50)	216 (52)	
Other ^b	2 (17)	3 (1)	
Clotting risks, No. (%) ^a			
Warfarin use	2 (17)	23 (6)	.13
Thrombocytopenia	0 (0)	7 (2)	.99
Cardiovascular risk, No. (%) ^{a,c}			.008 ^d
High	2 (17)	5 (1)	
Intermediate	9 (75)	281 (67)	
Low	1 (8)	105 (25)	
Tobacco use, No. (%) ^a			.52
Not current user	10 (83)	276 (66)	
Current user	2 (17)	115 (28)	
Alcohol use, No. (%) ^a			.29
None	10 (83)	243 (58)	
Current	2 (17)	135 (32)	
Diabetes, No. (%) ^a			.99
No	9 (75)	303 (72)	
Yes	3 (25)	94 (22)	
American Society of Anesthesiologists class, No. (%) ^a			.19
1	0 (0)	3 (1)	
2	1 (8)	138 (33)	
3	11 (92)	248 (59)	
4	0 (0)	9 (2)	
Metabolic equivalent of task, No. (%) ^a			.12
≥ 4	5 (42)	260 (62)	
< 4	7 (58)	129 (31)	
Preoperative laboratory tests, mean (SD)			
International normalized ratio	1.1 (0.15)	1.1 (0.19)	.32
Activated partial thrombosis time, sec	33.1 (22.6)	30.3 (6.4)	.74
Platelets, ×10 ³ /μL	219 (102)	228 (72)	.77
Albumin, g/dL	3.9 (0.4)	4.1 (0.4)	.14
Hemoglobin A _{1c} , %	5.7 (0.5)	6.3 (1.1)	.06
Hemoglobin, g/dL	12.4 (1.9)	14.5 (1.7)	.004 ^d
Hematocrit, %	36.9 (5.4)	42.7 (4.6)	.003 ^d

^aPercentages may not add up to 100.

^bIncludes Asian, Pacific Islander, Alaska Native, and no response.

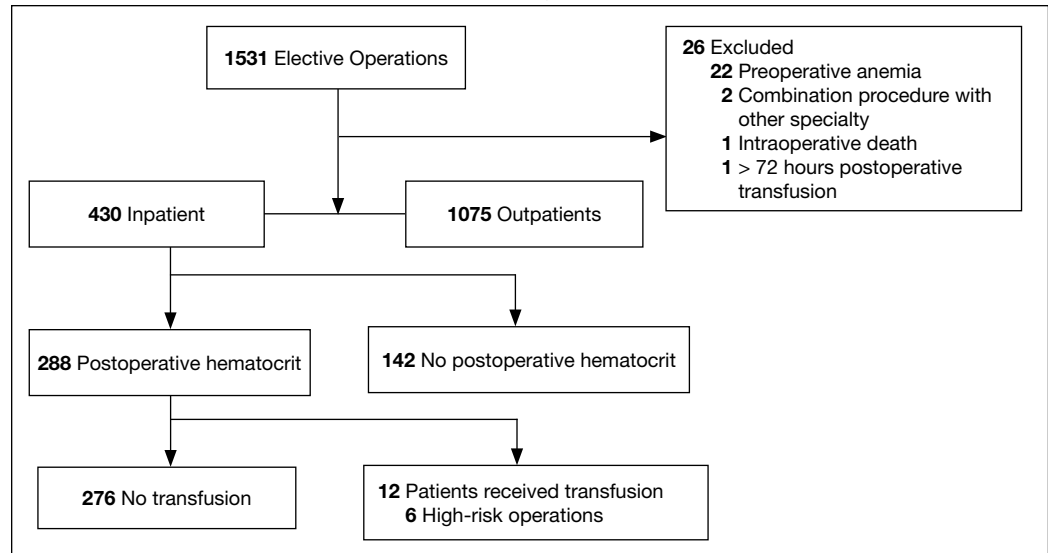
^cCardiovascular risk determined by anesthesiology assessment.

^dStatistically significant.

practice. One problem with checking the hematocrit routinely, as with any other screening test, is what to do with an abnormal result, assuming an asymptomatic patient? If the postoperative hematocrit is lower than expected given the estimated blood loss (EBL), what is one to do?

METHODS

This retrospective case-control study conducted at the New Mexico VA Health Care System (NMVAHCS) in Albuquerque compared data for patients who received transfusion within 72 hours of elective surgeries vs

FIGURE Flowchart of Patients in the Study

patients who did not. Patients who underwent elective general surgery from January 2011 through December 2014 were included. An elective general surgery was defined as surgery performed following an outpatient preoperative anesthesia evaluation ≥ 30 days prior to operation. Patients who underwent emergency operations, and those with baseline anemia (preoperative hematocrit $< 30\%$), and those transfused > 72 hours after their operation were excluded. The NMAVAHCS Institutional Review Board approved this study (No. 15-H184).

A detailed record review was conducted to collect data on demographics and other preoperative risk factors, including age, sex, body mass index (BMI), race and ethnicity, cardiac and pulmonary comorbidities, tobacco use, alcohol intake, diabetes, American Society of Anesthesiologists Physical Status Classification, metabolic equivalent of task, hematologic conditions, and renal disease.

For each procedure, we recorded the type of elective general surgery performed, the diagnosis/indication, pre- and postoperative hemoglobin/hematocrit, intraoperative EBL, length of operation, surgical wound class, length of hospital stay (LOS), intensive care unit (ICU) status, number of hematocrit tests, cardiovascular risk of operation (defined by anesthesia assessment), presence or absence of malignancy, preoperative platelet count, albumin level, preoperative prothrombin time/activated partial thromboplastin time (aPTT), interna-

tional normalized ratio (INR), hemoglobin A_{1c} , and incidence of transfusion. Signs and symptoms of anemia were recorded as present if the postoperative vital signs suggested low intravascular volume (pulse > 120 beats/minute, systolic blood pressure < 90 mm Hg, or vasoactive medication requirement [per anesthesia postoperative note]) or if the patient reported or exhibited symptoms of dizziness or fatigue or evidence of clinically apparent bleeding (ie, hematoma formation). Laboratory charges for hematocrit tests and CBC at the NMAVAHCS were used to assess cost.¹¹

To stratify the transfusion risk, patients were distributed among 3 groups based on the following criteria: discharged home the same day as surgery; admitted but did not have postoperative hematocrit testing; and admitted and had postoperative hematocrit testing. We also stratified operations into low or high risk based on the risk for postoperative transfusion (Figure). Recognizing that the American College of Chest Physicians guidelines for perioperative management of antithrombotic therapy places bowel resection in a high-risk category, we designated a surgery as high risk when ≥ 2 patients in the transfusion group had that type of surgery over the 4 years of the study.¹² Otherwise, the operations were deemed low risk.

Statistical Analysis

Numeric analysis used *t* tests and Binary and categorical variables used Fisher exact tests.

TABLE 2 Risk Factors Influencing Transfusion

Risk factors	Transfusion group (n = 12)	Nontransfusion group (n = 418)	P value
High-risk operation, No. (%)	6 (50)	16 (4)	< .00 ^a
Malignancy present, No. (%)	4 (33)	125 (30)	.99
Operative wound type, No. (%) ^b			.009 ^a
Clean	1 (8)	151 (36)	
Clean/contaminated	5 (42)	183 (44)	
Contaminated	5 (42)	48 (11)	
Dirty/infected	1 (8)	13 (3)	
Intraoperative, mean (SD)			
Estimated blood loss, mL	844 (721)	109 (150)	.005 ^a
Intraoperative fluids, mL	4625 (2094)	2505 (1550)	.005 ^a
Operative time, min	397 (158)	183 (115)	< .001 ^a
Postoperative systolic BP < 90 mm Hg or HR > 120 bpm, No. (%)	1 (8)	13 (3)	.34
Postoperative tests, mean (SD)			
Hemoglobin, g/dL	10.0 (1.8)	12.6 (2.3)	< .001 ^a
Hematocrit, %	30.2 (4.8)	37.1 (5.0)	< .001 ^a
Length of stay, mean (SD)	14.5 (6.7)	4.9 (5.0)	< .001 ^a
Intensive care unit stay, No. (%)	10 (83)	160 (38)	< .001 ^a
Postoperative hematocrit tests			
Mean (SD)	9.3 (6.5)	2.6 (3.7)	.004 ^a
Clinical rationale, No. (%)	9 (75)	63 (15)	< .001 ^a
Anemia symptoms or blood loss, No. (%)	5 (42)	23 (6)	< .001 ^a

Abbreviations: BP, blood pressure; bpm, beats per minute; HR, heart rate.

^aStatistically significant.

^bPercentages may not add up to 100.

P value ≤ .05 was considered statistically significant. SAS software was used for all statistical analyses.

RESULTS

From 2011 through 2014, 1531 patients had elective general surgery at NMVAHCS. Twenty-two patients with preoperative anemia (hematocrit < 30%) and 1 patient who received a transfusion > 72 hours after the operation were excluded. Most elective operations (70%, *n* = 1075) were performed on an outpatient basis; none involved transfusion. Inguinal hernia repair was most common with 479 operations; 17 patients were treated inpatient of which 2 patients had routine postoperative hematocrit checks; (neither received transfusion). One patient with inguinal hernia surgery received transfusion without routine postoperative hematocrit monitoring.

Of 112 partial colon resections, 1 patient had a postoperative transfusion; and all but 3

received postoperative hematocrit monitoring. Nineteen patients undergoing partial colon resection had a clinical indication for postoperative hematocrit monitoring. None of the 5 patients with partial gastrectomy received a postoperative transfusion. Of 121 elective cholecystectomies, no patients had postoperative transfusion, whereas 34 had postoperative hematocrit monitoring; only 2 patients had a clinical reason for the hematocrit monitoring.

Of 430 elective inpatient operations, 12 received transfusions and 288 patients had ≥ 1 postoperative hematocrit test (67%). All hematocrit tests were requested by the attending surgeon, resident surgeon, or the surgical ICU team. Of the group that had postoperative hematocrit monitoring, there was an average of 4.4 postoperative hematocrit tests per patient (range, 1-44).

There were 12 transfusions for inpatients (2.8%), which is similar to the findings of a

recent study of VA general surgery (2.3%).¹³ Five of the 12 patients received intraoperative transfusions while 7 were transfused within 72 hours postoperation. All but 1 patient receiving transfusion had EBL > 199 mL (range, 5-3000; mean, 950 mL; median, 500 mL) and/or signs or symptoms of anemia or other indications for measurement of the postoperative hematocrit. There were no statistically significant differences in patients' age, sex, BMI, or race and ethnicity between groups receiving and not receiving transfusion (Table 1).

When comparing the transfusion vs the nontransfusion groups (after excluding those with clinical preoperative anemia) the risk factors for transfusion included: relatively low mean preoperative hematocrit (mean, 36.9% vs 42.7%, respectively; $P = .003$), low postoperative hematocrit (mean, 30.2% vs 37.1%, respectively; $P < .001$), high EBL (mean, 844 mL vs 109 mL, respectively; $P = .005$), large infusion of intraoperative fluids (mean, 4625 mL vs 2505 mL, respectively; $P = .005$), longer duration of operation (mean, 397 min vs 183 min, respectively; $P < .001$), and longer LOS (mean, 14.5 d vs 4.9 d, respectively; $P < .001$) (Table 2). Similarly, we found an increased risk for transfusion with high/intermediate cardiovascular risk (vs low), any wound not classified as clean, ICU stay, and postoperative symptoms of anemia.

We found no increased risk for transfusion with ethanol, tobacco, warfarin, or clopidogrel use; polycythemia; thrombocytopenia; preoperative INR; preoperative aPTT; preoperative albumin; Hemoglobin A_{1c}; or diabetes mellitus; or for operations performed for malignancy. Ten patients in the ICU received transfusion (5.8%) compared with 2 patients (0.8%) not admitted to the ICU.

Operations were deemed high risk when ≥ 2 of patients having that operation received transfusions within 72 hours of their operation. There were 15 abdominoperineal resections; 3 of these received transfusions (20%). There were 7 total abdominal colectomies; 3 of these received transfusions (43%). We therefore had 22 high-risk operations, 6 of which were transfused (27%).

DISCUSSION

Routine measurement of postoperative hematocrit levels after elective general surgery at NMVAHCS was not necessary. There were

12 transfusions for inpatients (2.8%), which is similar to the findings of a recent study of VA general surgery (2.3%).¹³ We found that routine postoperative hematocrit measurements to assess anemia had little or no effect on clinical decision-making or clinical outcomes.

According to our results, 88% of initial hematocrit tests after elective partial colectomies could have been eliminated; only 32 of 146 patients demonstrated a clinical reason for postoperative hematocrit testing. Similarly, 36 of 40 postcholecystectomy hematocrit tests (90%) could have been eliminated had the surgeons relied on clinical signs indicating possible postoperative anemia (none were transfused). Excluding patients with major intraoperative blood loss (> 300 mL), only 29 of 288 (10%) patients who had postoperative hematocrit tests had a clinical indication for a postoperative hematocrit test (ie, symptoms of anemia and/or active bleeding). One patient with inguinal hernia surgery who received transfusion was taking an anticoagulant and had a clinically indicated hematocrit test for a large hematoma that eventually required reoperation.

Our study found that routine hematocrit checks may actually increase the risk that a patient would receive an unnecessary transfusion. For instance, one elderly patient, after a right colectomy, had 6 hematocrit levels while on a heparin drip and received transfusion despite being asymptomatic. His lowest hematocrit level prior to transfusion was 23.7%. This patient had a total of 18 hematocrit tests. His EBL was 350 mL and his first postoperative HCT level was 33.1%. In another instance, a patient undergoing abdominoperineal resection had a transfusion on postoperative day 1, despite being hypertensive, with a hematocrit that ranged from 26% before transfusion to 31% after the transfusion. These 2 cases illustrate what has been shown in a recent study: A substantial number of patients with colorectal cancer receive unnecessary transfusions.¹⁴ On the other hand, one ileostomy closure patient had 33 hematocrit tests, yet his initial postoperative hematocrit was 37%, and he never received a transfusion. With low-risk surgeries, clinical judgment should dictate when a postoperative hematocrit level is needed. This strategy would have eliminated 206 unnecessary initial postoperative hematocrit tests (72%),

could have decreased the number of unnecessary transfusions, and would have saved NMVAHCS about \$1600 annually.

Abdominoperineal resections and total abdominal colectomies accounted for a high proportion of transfusions in our study. Inpatient elective operations can be risk stratified and have routine hematocrit tests ordered for patients at high risk. The probability of transfusion was greater in high-risk vs low-risk surgeries; 27% (6 of 22 patients) vs 2% (6 of 408 patients), respectively ($P < .001$). Since 14 of the 22 patients undergoing high-risk operation already had clinical reasons for a postoperative hematocrit test, we only need to add the remaining 8 patients with high-risk operations to the 74 who had a clinical reason for a hematocrit test and conclude that 82 of 430 patients (19%) had a clinical reason for a hematocrit test, either from signs or symptoms of blood loss or because they were in a high-risk group.

While our elective general surgery cases may not represent many general surgery programs in the US and VA health care systems, we can extrapolate cost savings using the same cost analyses outlined by Kohli and colleagues.¹ Assuming 1.9 million elective inpatient general surgeries per year in the United States with an average cost of \$21 per CBC, the annual cost of universal postoperative hematocrit testing would be \$40 million.^{11,15} If postoperative hematocrit testing were 70% consistent with our findings, the annual cost for hematocrit tests on 51% of the inpatient general surgeries would be approximately \$20.4 million. A reduction in routine hematocrit testing to 25% of all inpatient general surgeries (vs our finding that 19% were deemed necessary) results in an annual savings of \$30 million. This conservative estimate could be even higher since there were 4.4 hematocrit tests per patient; therefore, we have about \$132 million in savings.

Assuming 181,384 elective VA inpatient general surgeries each year, costing \$7.14 per CBC (the NMVAHCS cost), the VA could save \$1.3 million annually. If postoperative HCT testing were 70% consistent with our findings, the annual cost for hematocrit tests on 50.4% of inpatient general surgery operations would be about \$653,000. A reduction in routine hematocrit testing to 25% of all inpatient general surgeries (vs our 19%) results in annual VA savings of \$330,000. This conservative estimate could be even higher since there were on average 4.4 hematocrit levels per patient;

therefore, we estimate that annual savings for the VA of about \$1.45 million.

Limitations

The retrospective chart review nature of this study may have led to selection bias. Only a small number of patients received a transfusion, which may have skewed the data. This study population comes from a single VA medical center; this patient population may not be reflective of other VA medical centers or the US population as a whole. Given that NMVAHCS does not perform hepatic, esophageal, pancreas, or transplant operations, the potential savings to both the US and the VA may be overestimated, but this could be studied in the future by VA medical centers that perform more complex operations.

CONCLUSIONS

This study found that over a 4-year period routine postoperative hematocrit tests for patients undergoing elective general surgery at a VA medical center were not necessary. General surgeons routinely order various pre- and postoperative laboratory tests despite their limited utility. Reduction in unneeded routine tests could result in notable savings to the VA without compromising quality of care.

Only general surgery patients undergoing operations that carry a high risk for needing a blood transfusion should have a routine postoperative hematocrit testing. In our study population, the chance of an elective colectomy, cholecystectomy, or hernia patient needing a transfusion was rare. This strategy could eliminate a considerable number of unnecessary blood tests and would potentially yield significant savings.

Author affiliations

^aNew Mexico Veterans Affairs Health Care System, Albuquerque

^bUniversity of New Mexico School of Medicine, Albuquerque

^cHarbor-UCLA Medical Center, Torrance, California

^dOregon Health and Science University, Portland

Author contributions

Study conception and design: Vigil, Taylor; *acquisition of data:* Vigil, Taylor, Geuss, Mercer; *analysis and interpretation of data:* Vigil, Taylor, Osofsky, Qualls; *drafting of manuscript:* Vigil, Taylor; *critical revision:* Glew.

Author disclosures

The authors report no actual or potential conflicts of interest or outside sources of funding with regard to this article.

Disclaimer

The opinions expressed herein are those of the authors and do not necessarily reflect those of *Federal Practitioner*,

Frontline Medical Communications Inc., the US Government, or any of its agencies. This article may discuss unlabeled or investigational use of certain drugs. Please review the complete prescribing information for specific drugs or drug combinations—including indications, contraindications, warnings, and adverse effects—before administering pharmacologic therapy to patients.

Ethics and consent

The New Mexico Veterans Affairs Health Care System Institutional Review Board approved this study (No. 15-H184).

References

- Kohli N, Mallipeddi PK, Neff JM, Sze EH, Roat TW. Routine hematocrit after elective gynecologic surgery. *Obstet Gynecol.* 2000;95(6 Pt 1):847-850. doi:10.1016/s0029-7844(00)00796-1
- Olus A, Orhan, U, Murat A, et al. Do asymptomatic patients require routine hemoglobin testing following uneventful, unplanned cesarean sections? *Arch Gynecol Obstet.* 2010;281(2):195-199. doi:10.1007/s00404-009-1093-1
- Wu XD, Zhu ZL, Xiao P, Liu JC, Wang JW, Huang W. Are routine postoperative laboratory tests necessary after primary total hip arthroplasty? *J Arthroplasty.* 2020;35(10):2892-2898. doi:10.1016/j.arth.2020.04.097
- Kumar A, Srivastava U. Role of routine laboratory investigations in preoperative evaluation. *J Anesthesiol Clin Pharmacol.* 2011;27(2):174-179. doi:10.4103/0970-9185.81824
- Aghajanian A, Grimes DA. Routine prothrombin time determination before elective gynecologic operations. *Obstet Gynecol.* 1991;78(5 Pt 1):837-839.
- Ransom SB, McNeeley SG, Malone JM Jr. A cost-effectiveness evaluation of preoperative type-and-screen testing for vaginal hysterectomy. *Am J Obstet Gynecol.* 1996;175(5):1201-1203. doi:10.1016/s0002-9378(96)70028-5
- Ransom SB, McNeeley SG, Hosseini RB. Cost-effectiveness of routine blood type and screen testing before elective laparoscopy. *Obstet Gynecol.* 1995;86(3):346-348. doi:10.1016/0029-7844(95)00187-V
- Committee on Standards and Practice Parameters, Apfelbaum JL, Connis RT, et al. Practice advisory for pre-anesthesia evaluation: an updated report by the American Society of Anesthesiologists Task Force on Preanesthesia Evaluation. *Anesthesiology.* 2012;116(3):522-538. doi:10.1097/ALN.0b013e31823c1067
- Weil IA, Seicean S, Neuhauser D, Schiltz NK, Seicean A. Use and utility of hemostatic screening in adults undergoing elective, non-cardiac surgery. *PLoS One.* 2015;10(12):e0139139. doi:10.1371/journal.pone.0139139
- Wu WC, Schiffner TL, Henderson WG, et al. Preoperative hematocrit levels and postoperative outcomes in older patients undergoing non-cardiac surgery. *JAMA.* 2007;297(22):2481-2488. doi:10.1001/jama.297.22.2481
- Healthcare Bluebook. Complete blood count (CBC) with differential. Accessed March 28, 2024. https://www.healthcarebluebook.com/page_ProcedureDetails.aspx?id=214&dataset=lab
- Douketis JD, Spyropoulos AC, Murad MH, et al. Perioperative management of antithrombotic therapy: an American College of Chest Physicians Clinical Practice Guideline. *Chest.* 2022;162(5):e207-e243. doi:10.1016/j.chest.2022.07.025
- Randall JA, Wagner KT, Brody F. Perioperative transfusions in veterans following noncardiac procedures. *J Laparoendosc Adv Surg Tech A.* 2023;33(10):923-931. doi:10.1089/lap.2023.0307
- Tarttter PI, Barron DM. Unnecessary blood transfusions in elective colorectal cancer surgery. *Transfusion.* 1985;25(2):113-115. doi:10.1046/j.1537-2995.1985.25285169199.x
- Steiner CA, Karaca Z, Moore BJ, Imshaug MC, Pickens G. Surgeries in hospital-based ambulatory surgery and hospital inpatient settings, 2014. Healthcare Cost and Utilization Project statistical brief #223. May 2017. Revised July 2020. Agency for Healthcare Research and Quality. Accessed February 26, 2024. <https://hcup-us.ahrq.gov/reports/statbriefs/sb223-Ambulatory-Inpatient-Surgeries-2014.pdf>
- US Department of Veterans Affairs, National Surgery Office. Quarterly report: Q3 of fiscal year 2017. VISN operative complexity summary [Source not verified].