Original Article

Does blood transfusion type affect complication and length of stay following same-day bilateral total knee arthroplasty?

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ABSTRACT

Same-day Bilateral Total Knee Arthroplasty (BTKA) safety is still controversial. The aim of this study was to examine the association of blood transfusion type (pure autologous, pure allogeneic, and combined) with complication and prolonged length of stay (PLOS) following same-day BTKA. 649 consecutive patients were retrospectively identified over a two-year period.

Pure allogeneic transfusions were associated with increased odds of minor complication when compared to patients who had pure autologous transfusions. No association was found between blood transfusion type and major complication or PLOS. Our results suggest that blood transfusion type may be influential in minor complication after BTKA.

1. Introduction

Even though, same-day BTKA (simultaneous or sequential) is a widely accepted procedure in the contemporary orthopedic armamentarium,¹ potential effect on patient morbidity is still nebulous in the literature. This double “surgical hit” has been associated with increased complications,^{2–5} mortality^{4,5} and hospital LOS^{3,5–7} when compared to unilateral TKA or staged BTKA. However, other authors^{3–11} consider this approach as relatively safe especially when proper patient selection criteria are applied.

On the other hand, many studies report worse outcomes in patients receiving blood transfusions compared to non-transfused patients in various medical settings including TKA, although these adverse outcomes may be partly attributable to other confounders.¹² The fact that, transfusion rates are higher in same-day BTKA than unilateral TKA or staged BTKA,^{9,13–15} highlights even more the potential effect of transfusion on complication rate in these patients. Moreover, allogeneic blood transfusion has been associated with increased LOS after unilateral TKA.^{16,17} However, it has not been clarified yet in the literature, whether the type of transfusion (autologous, allogeneic or combined) might be associated with the development of complications in a same-day BTKA patient cohort and affect hospital LOS.

2. Patients and methods

2.1. Patient population

This is a retrospective study of 649 patients undergone same-day (sequential) BTKA over a 2-year period from 1 January 2008 to 31 December 2009 in a high volume institution. Same-day BTKA patients had two primary TKA procedure codes during a single admission with the same procedure date, as defined by discharge coding rules. An appropriate institutional review board (IRB) approved the project (IRB# 29141). Eligibility for same-day operation was depended upon fulfilling our suggested institutional criteria (Table 1). However, in rare occasions and after thorough deliberation of risks and benefits, patients were deemed candidates for BTKA even if they had any of these exclusion criteria. Excluded patients with bilateral disease were scheduled for staged BTKA procedure. The procedures followed, were in accordance with the ethical standards of the responsible institutional committee on human experimentation.

2.2. Surgical protocol

All surgeries were performed by a fellowship trained and highly

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Table 1
Suggested institutional exclusion criteria for same-day BTKA.

1. Patients $\geq$ 80 years old.
2. All ASA III patients.
3. Active ischemic heart disease (positive stress test or a history of anginal equivalents).
4. Decreased LV function (LVEF < 45%). Patients with symptoms of DOE, SOB, or poor functional capacity should have a preoperative echocardiogram.
5. Pulmonary disease: moderate to severe pulmonary hypertension; Oxygen dependent pulmonary disease; oral steroid dependent asthma; exercise limiting COPD.
6. Morbid obesity (BMI > 40). (Unless the patient has no other systemic comorbidity; e.g. HTN, DM, IHD, Pulmonary HTN).
7. Renal Insufficiency (Cr > 1.6).
8. Chronic Liver Disease (functional impairment in liver function and/or ascites; Child's Class B or greater).
9. Poorly controlled diabetes; Hgb A1c > 7%.
10. Cerebral Vascular Disease with history of stroke.
11. Major peripheral Vascular Disease involving the lower extremities with stents or vascular bypass (exceptions would require a vascular consult).
12. In hospital staged BTKA; when considered necessary for rehabilitation, the case must first be reviewed by the Complex Case Committee.

ASA: American Society of anesthesiologists; LV: Left Ventricle; LVEF: Left Ventricular Ejection Fraction; DOE: Dyspnea On Exertion; SOB: Shortness Of Breath; COPD: Chronic Obstructive Pulmonary Disease; BMI: Body Mass Index; HTN: Hypertension; DM: Diabetes Mellitus; IHD: Ischemic Heart Disease; Cr: Creatinine; Hgb: Hemoglobin.

experienced group of orthopedic surgeons. The two procedures were performed sequentially, starting from the most painful joint. Cemented posterior stabilized prostheses were implanted in all patients following standard midline incision and medial parapatellar arthrotomy. Both procedures were done under pneumatic tourniquet control. Preoperatively, patients were advised to donate autologous blood in a case by case basis.^{18,19} The donation period began 4 to 6 weeks before surgery in order to optimize the balance between the length of allowable storage time and time for regeneration of blood cells. Orthopedic Perioperative Auto-Transfusion system OrthoPAT® (Transfusion Technologies Corporation, Natick, MA) was used intra- and postoperatively when: 1) high blood loss was anticipated (coagulopathy or complex procedures), and/or 2) allogeneic transfusion would not be possible (compatibility issues or religious beliefs), and/or 3) the patient was unable to donate sufficient quantities of autologous blood prior to surgery to adequately cover the anticipated transfusion requirement. After the operation, patients were transferred to post-anesthesia care unit (PACU) for 12–24 h. Subsequently, when hemodynamic status, urine output and pain control were deemed acceptable, patients were transferred to the orthopedic wards. Discharge from hospital was allowed when meeting rehabilitation criteria. All patients received postoperative thromboembolic prophylaxis for 4–6 weeks.

2.3. Transfusion criteria

Our institution transfusion criteria included: 1) Hemoglobin (Hgb) < 8 g/dL not due to iron, folate or vitamin B₁₂ deficiency (only if clinically indicated), 2) Actively bleeding and clinically unstable patient, 3) Hgb < 10 g/dL and coexisting cardiac, pulmonary or cerebrovascular disease; symptoms of decreased O₂ delivery; or patient on chronic transfusion regimen.

2.4. Study measures

Patient demographic and clinical data were recorded (Table 2). Depending on transfusion status they were divided in four groups: 0 (not transfused), 1 (pure autologous transfusion), 2 (pure allogeneic transfusion) and 3 (combined autologous and allogeneic transfusion). Transfusion status was based on International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes: 99.00–99.04. Autologous transfusion was defined as the transfusion of preoperative

Table 2
Descriptive data for the total cohort (n = 649).

Characteristic	Value
Age (mean $\pm$ SD)	65.09 $\pm$ 8.78
Sex (%)	
Male	239 (36.83)
Female	410 (63.17)
ASA status (%) (n = 604)	
1	17 (2.81)
2	529 (87.58)
3	58 (9.6)
OrthoPAT® use (%)	
Yes	250 (38.52)
No	399 (61.48)
Units received (%)	
0	61 (9.4)
1	120 (18.49)
2	268 (41.29)
3	129 (19.88)
4	48 (7.4)
5	17 (2.62)
6	6 (0.92)
Transfusion (%)	
No	61 (9.41)
Pure autologous	336 (51.77)
Pure allogeneic	79 (12.17)
Combined	173 (26.65)
Complications (%)	
Major	17 (2.62)
Minor	62 (9.55)
Local	1 (0.15)
None	569 (87.68)
LOS (%)	
Regular ($\leq$ 5 days)	609 (93.84)
Prolonged (> 5 days)	40 (6.16)

SD: Standard deviation; ASA: American Society of anesthesiologists; OrthoPAT®: Orthopedic Perioperative Auto-Transfusion system; LOS: Length of stay.

blood donated by the same patient.

Complications were classified as major, minor and local (orthopedic) adopting a previous published system^{9,20} based on ICD-9-CM coding (Table 3). Only complications during admission for index surgery (in-hospital) were evaluated and were recorded as per patient. Complications were classified as major if they required complex surgical or medical intervention or they were deemed life-threatening or resulted in functional impairment. Minor complications included those that required medical treatment or necessitated additional observation. Finally, intra- and postoperative surgical site complications were considered as local.

LOS was also recorded and counted in whole days as the number of postoperative nights in the hospital. LOS greater than 5 days was considered prolonged.

2.5. Statistical analysis

Descriptive statistics were calculated to examine patient characteristics, transfusion data, complication rates and LOS. Means and standard deviations are reported for continuous variables and frequencies and percent for categorical variables. The association between transfusion type and the outcomes of complication (major and minor) and PLOS was examined using multivariable logistic regressions. Statistical significance was set at $p < 0.05$.

3. Results

Mean patient age was 65.09 $\pm$ 8.78 years and 36.83% were male. American Society of anesthesiologists (ASA) physical status was documented for 604 patients. Among them, 17 were classified as ASA 1 (2.81%), 529 as ASA 2 (87.58%) and 58 as ASA 3 (9.6%). Mean

Table 3

ICD-9-CM diagnosis codes for Local, Minor and Major Complication.

Variables	ICD-9 codes
Local complication	
Injury to peripheral nerve(s) of pelvic girdle and lower limb	956.X
Peripheral vascular complications	997.2
Hemorrhage complicating a procedure	998.11
Hematoma complicating a procedure	998.12
Seroma complicating a procedure	998.13
Accidental puncture or laceration during a procedure	998.2
Disruption of operative wound	998.3
Disruption of internal operation wound	998.31
Disruption of external operation wound	998.32
Nonhealing surgical wound	998.83
Minor complication	
Hypotension	458.2, 458.29, 458.9
Syncope and collapse	780.2
Tachycardia	785.0
Delirium	292.81, 293.0, 293.1
Urinary tract infection	599.0
Urinary retention	788.2X
Postoperative infection and cellulitis	998.5X, 999.3X, 682.6
Paralytic ileus	560.1
Pleural effusion	511.9
Major complication	
Central nervous system infarction	997.01, 997.02
Pulmonary compromise	518.X, 997.3X
Sepsis	038.X, 785.52, 785.59, 790.7, 995.91, 995.92, 998.0
Shock/cardiopulmonary arrest	427.5, 799.1
Acute myocardial infarction	410.01, 410.11, 410.21, 410.31, 410.41, 410.51, 410.61, 410.71, 410.81, 410.91
Cardiac complications	997.1X
Pneumonia	480.X, 481, 482.X, 483.X, 485, 486, 487.0, 507.0
Pulmonary embolism	415.11, 415.12, 415.19
Embolism/thrombosis – deep vein thrombosis	453.8, 453.41, 453.42

X indicates that the variable includes all codes starting with the numbers preceding the X.; ICD-9-CM: International Classification of Diseases, 9th Revision, Clinical Modification.

Table 4

Odds ratios for major complication.

Variable of interest	Unadjusted OR	Adjusted OR (95% CI)	P value
BT group (0 vs 1)	< 0.001	< 0.001 (< 0.001– > 999.99)	0.975
BT group (2 vs 1)	< 0.001	1.06 (0.12–9.81)	0.958
BT group (3 vs 1)	< 0.001	3.32 (0.72–15.36)	0.124
OrthoPAT® (Yes vs No)	0.48	0.55 (0.14–2.09)	0.378
Units received	1.60	0.98 (0.51–1.89)	0.962

BT: Blood Transfusion; OrthoPAT®: Orthopedic Perioperative Auto-Transfusion system; OR: Odds Ratio; CI: Confidence Intervals.

Table 5

Odds ratios for minor complication.

Variable of interest	Unadjusted OR	Adjusted OR (95% CI)	P value
BT group (0 vs 1)	2.17	0.66 (0.13–3.26)	0.607
BT group (2 vs 1)	8.71	3.10 (1.42–6.76)	0.004
BT group (3 vs 1)	3.64	1.31 (0.59–2.93)	0.507
OrthoPAT® (Yes vs No)	1.17	1.60 (0.89–2.87)	0.118
Units received	1.32	1.16 (0.84–1.61)	0.361

BT: Blood Transfusion; OrthoPAT®: Orthopedic Perioperative Auto-Transfusion system; OR: Odds Ratio; CI: Confidence Intervals.

Table 6

Odds ratios for prolonged length of stay.

Variable of interest	Unadjusted OR	Adjusted OR (95% CI)	P value
BT group (0 vs 1)	1.19	1.07 (0.19–5.93)	0.940
BT group (2 vs 1)	3.79	2.38 (0.83–6.79)	0.105
BT group (3 vs 1)	3.01	2.23 (0.84–5.93)	0.108
OrthoPAT® (Yes vs No)	0.44	0.53 (0.23–1.21)	0.132
Units received	1.45	1.12 (0.76–1.65)	0.575

BT: Blood Transfusion; OrthoPAT®: Orthopedic Perioperative Auto-Transfusion system; OR: Odds Ratio; CI: Confidence Intervals.

anesthesia time was 180.27 ± 41.78 min. Complications were developed in 80 patients (12.33%). 17 patients (2.62%) developed major, 62 patients (9.55%) minor, and 1 patient (0.15%) local complication. Transfusion was required in 588 patients (90.6%). Among transfused patients, 336 (57.14%) received only autologous blood, 79 (13.44%) only allogeneic, and 173 (29.42%) received both autologous and allogeneic. Mean LOS was 4.51 ± 1.34 days for the whole cohort, and 4.23 ± 1.25 days for patients not transfused. No association was found between transfusion type and major complication in the multivariable logistic regression (Table 4). However, a significant association was observed between transfusion type and minor complication (not transfused: 3.23% vs. autologous: 37.1% vs. allogeneic: 29.03% vs. combined: 30.65%; $p < 0.0001$). After adjustment (Table 5), the odds of a minor complication increased given a pure autologous transfusion when compared to those who had pure autologous transfusions [OR = 3.10 (95% CI = 1.42–6.76); $p = 0.004$]. Local complication outcome was not studied since only 1 patient developed one. Combined blood transfused patients accounted for the highest percentage of patients with PLOS (not transfused: 5% vs. autologous: 32.5% vs. allogeneic: 22.5% vs. combined: 40%; $p < 0.0146$). However, no association was found between blood transfusion type and PLOS (Table 6).

4. Discussion

Preoperative autologous blood donation (PAD) and subsequent postoperative autologous transfusion is a common practice in same-day BTKA.^{19,21} Surgeons and patients share an indisputable preference to autologous blood, trying to avoid adverse reactions directly associated with allogeneic blood like infectious diseases transmission and immune reactions.²² PAD seems an effective strategy towards this direction.²³

Moreover, association between allogeneic blood transfusion and postoperative morbidity has been documented in unilateral TKA. In a 4,544,999 patients cohort, allogeneic transfusion (pure or combined with autologous) was associated with poorer surgical and medical outcomes following unilateral TKA between the years 2000–2009.¹⁶ However, the comparative group was non-transfused patients. On the other hand, Hart et al²⁴ failed to correlate transfusion (autologous or allogeneic) with thirty-day complication rates after unilateral TKA. Multivariate logistic regression showed that mortality was the only outcome associated with transfusion. The potentially different effect on complication burden between autologous and allogeneic transfused blood has not been clarified in the literature yet.

Following BTKA, morbidity risk factors have been already studied.^{9,25–27} However, blood transfusion type as a risk factor for complications has not been evaluated yet. To the best of our knowledge, present study is the first who directly compares the development of systemic major or minor and local complication between patient groups receiving pure autologous, pure allogeneic or combined transfusion in a same-day BTKA cohort. Since, local complication rate was extremely low – 0.15% (1 patient), this outcome was not included in final analyses. Multivariate analysis documented blood type effect in minor complication outcome. Patients transfused with allogeneic blood had a 210% greater chance of developing a minor complication compared to patients receiving only autologous blood. Same outcome failed to prove

difference between autologous and combined transfusion groups. The need for less allogeneic blood for patients already receiving their own blood is a potential explanation for this disparity.

The use of OrthoPAT[®] is a documented blood conserving method in unilateral TKA²⁸ and BTKA.^{19,21} Shen et al²⁸ found a reduction in postoperative complications when comparing OrthoPAT[®] and allogeneic transfusion in unilateral TKA. In our study, OrthoPAT[®] was not associated with systemic minor or major complication development, but it was not used as a separate blood management tool.

Our overall and categorical complication rates are better than those reported earlier²⁹ in the same institution, in accordance with the trend analysis by Poultides et al.³⁰ Proper patient selection criteria and optimization of perioperative patient management justifies the reduction in complication over time in BTKA surgery.

In unilateral TKA, Menendez et al,¹⁷ found that transfusion rates were directly associated with LOS. Hospitals in the lowest tertile of blood transfusion use compared to hospitals in the highest tertile were 60% (95% CI, 36–87%) more likely to have a LOS greater than 3 days (> 75th percentile). However, they evaluated only allogeneically transfused patients. In our study, blood transfusion type and transfused blood units number failed to prove a significant risk factor for PLOS. Study of a larger patient cohort could potentially modify these results.

On the other hand, Gromov et al¹ studied risk factors for PLOS (> 5 days) after same-day BTKA in a fast-track setting. After adjusting for age, sex, ASA score and Body Mass Index (BMI), they found that only ASA score 3 was an independent risk factor for PLOS. Similarly, ASA score ≥ 3 among other factors was associated with length of stay ≥ 4 days in a unilateral TKA patient group.³¹ In our cohort, ASA failed to reach statistical significance in the univariate analysis.

Our study has several limitations. Patients were operated by a number of different surgeons. Slight modifications of the surgical technique and heterogeneous adherence to the transfusion criteria could be anticipated. Secondly, we evaluated data only for in-hospital complications during admission for index surgery. Potential complications during post-discharge follow-up were not recorded leading to possible under-estimation of complication rate in our cohort. Moreover, the use of ICD-9-CM codes to identify complications cannot rule out the possibility of coding errors. Another drawback is that our total patient cohort was derived from a single high-volume center which specialize in same-day BTKA. Respective complication rates may be different in other centers and our results should not be considered applicable in all centers and patients.

Lastly, the present study was conducted in the pre-Transexamic acid (TXA) era and could be considered rather historic. Nowadays, it is well known that TXA use is an established blood management strategy in the knee arthroplasty field. Any effort of translating our results in the contemporary practice should be done cautiously in the light of this issue. Moreover, even if future studies confirm any association between allogeneic transfusion type and minor complication, potential detrimental effect of minor complication on patient satisfaction and in-patient hospital charges should be additionally clarified.

5. Conclusion

Our results highlight that emphasis on blood transfusion type may not be warranted. However, allogeneic transfusion may not be favorable when compared to autologous transfusions with regards to minor complication. Additional studies should explore the beneficial aspects of autologous donation and transfusion with the new advancements in clinical practice, especially the use of TXA.

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Conflict of interest

Thomas Sculco declares that a) he has received IP royalties from Exactech Inc., b) he is an unpaid consultant for Lima Orthopedic, c) he is an editorial board member of the American Journal of Orthopedics and d) he is the president of the Knee Society. The other authors declare that they do not have any conflict of interest.

Author contribution

Vasileios Soranoglou: Conception and design of study, Data collection, Analysis and interpretation of data, Drafting of article and/or critical revision, Final approval of manuscript.

Lazaros Poultides: Conception and design of study, Data collection, Analysis and interpretation of data, Drafting of article and/or critical revision, Final approval of manuscript.

Florian Wanivenhaus: Data collection, Drafting of article and/or critical revision, Final approval of manuscript.

Allina Nocon: Conception and design of study, Analysis and interpretation of data, Drafting of article and/or critical revision, Final approval of manuscript.

Georgios Triantafyllopoulos: Analysis and interpretation of data, Drafting of article and/or critical revision, Final approval of manuscript.

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Thomas Sculco: Analysis and interpretation of data, Drafting of article and/or critical revision, Final approval of manuscript.

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