Effectiveness of preoperative autologous blood donation for protection against allogeneic blood exposure in adult spinal deformity surgeries: a propensity-matched cohort analysis

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Abstract

OBJECT—The goal of this study was to examine the effectiveness of preoperative autologous blood donation (PABD) in adult spinal deformity (ASD) surgery.

METHODS—Patients undergoing single-stay ASD reconstructions were identified in a multicenter database. Patients were divided into groups according to PABD (either PABD or NoPABD). Propensity weighting was used to create matched cohorts of PABD and NoPABD patients. Allogeneic (ALLO) exposure, autologous (AUTO) wastage (unused AUTO), and complication rates were compared between groups.

RESULTS—Four hundred twenty-eight patients were identified as meeting eligibility criteria. Sixty patients were treated with PABD, of whom 50 were matched to 50 patients who were not treated with PABD (NoPABD). Nearly one-third of patients in the PABD group (18/60, 30%) did not receive any autologous transfusion and donated blood was wasted. In 6 of these cases (6/60, 10%), patients received ALLO blood transfusions without AUTO. In 9 cases (9/60, 15%), patients received ALLO and AUTO blood transfusions. Overall rates of transfusion of any type were similar between groups (PABD 70% [42/60], NoPABD 75% [275/368], p = 0.438). Major and minor in-hospital complications were similar between groups (Major PABD 10% [6/60], NoPABD 12% [43/368], p = 0.537; Minor PABD 30% [18/60], NoPABD 24% [87/368], p = 0.499). When controlling for potential confounders, PABD patients were more likely to receive some transfusion (OR 15.1, 95% CI 2.1–106.7). No relationship between PABD and ALLO blood exposure was observed, however, refuting the concept that PABD is protective against ALLO blood exposure. In the matched cohorts, PABD patients were more likely to sustain a major perioperative cardiac complication (PABD 8/50 [16%], NoPABD 1/50 [2%], p = 0.046). No differences in rates of infection or wound-healing complications were observed between cohorts.

CONCLUSIONS—Preoperative autologous blood donation was associated with a higher probability of perioperative transfusions of any type in patients with ASD. No protective effect of PABD against ALLO blood exposure was observed, and no risk of perioperative infectious complications was observed in patients exposed to ALLO blood only. The benefit of PABD in patients with ASD remains undefined.

Keywords

Complex adult spinal deformity (ASD) surgeries are increasing in incidence, as the population ages and the revision burden grows.[15,16] Reconstructive surgeries for ASD are associated with long operative times and high estimated blood losses (EBLs). Consequently, resuscitation of these patients frequently requires transfusions of autologous (AUTO) or allogeneic (ALLO) packed red blood cells (PRBCs) to maintain circulating hemoglobin

levels, in an effort to minimize perioperative complications.[18] In fact, spine surgery is one of the most common procedures associated with PRBC transfusion in the US.[21,28]

Transfusion of ALLO PRBCs is not without risk. Beyond the low risk of exposure to disease, a systemic inflammatory response occurs in response to proteins carried with the PRBCs.[20,24,25] The most extreme of these inflammatory responses are known as transfusion-related acute lung injury and transfusion-associated circulatory overload, which carry risks of morbidity and mortality.[22] Less extreme, but also concerning, is the increased risk of perioperative complications, particularly infections, related to exposure to ALLO PRBCs.[2,8,26] This relationship has been shown in retrospective studies of patients with total joint arthroplasty and lumbar arthrodesis.[2,26]

An alternative to transfusion of ALLO blood is preoperative autologous blood donation (PABD) for postoperative transfusion. This hopefully eliminates or minimizes exposure to ALLO blood products.[11] This modality is imperfect, however, as it may create an iatrogenic anemia, increasing the chance of requiring a postoperative transfusion, coupled with a lower transfusion threshold because of a belief that AUTO blood should be used.[11,12] Autologous blood frequently goes unused and is wasted.[1] Finally, transfusion errors can occur and, despite PABD, patients are erroneously transfused with ALLO blood. Despite these negative features, PABD is still performed, due probably in part to physician and patient preferences to avoid ALLO blood exposure.[9,10]

The purpose of this study was to examine the use of PABD in a large cohort of patients with ASD. We sought to investigate the following: 1) the protective effect of PABD against exposure to ALLO blood; 2) the rates of blood wastage (unused PABD); and 3) the impact of AUTO and ALLO blood exposure on perioperative complications.

Methods

Patients undergoing surgery for ASD in a single hospital stay were identified in a multicenter cohort of patients with ASD from 11 sites in the US. Patients undergoing staged surgeries (anterior and posterior) within the same hospital stay were included in the cohort analyzed. Patients undergoing staged surgeries during separate hospital stays were excluded from the cohort. All sites received institutional review board approval. Eligibility criteria for inclusion in this cohort were age > 18 years, the presence of a spinal deformity with scoliosis > 20°, sagittal vertical axis > 5 cm, pelvic tilt > 25°, and/or a thoracic kyphosis 60°. Patients were excluded if they had a concomitant diagnosis of neuromuscular disease, infection, or malignancy.

Preoperative demographic data collected included age at surgery, sex, body mass index (BMI; m/kg^2), Charlson Comorbidity Index (CCI) score, nicotine use, and medical comorbidities. Comorbidities collected included those associated with perioperative complications, such as diabetes mellitus, and those associated with higher risks of perioperative blood transfusion, such as cardiovascular diagnoses. PABD was performed at the surgeon's discretion and the volume donated was recorded.

Surgical data collected included whether the surgery was a primary or revision procedure; operative time; EBL; whether surgery was anterior, posterior, or circumferential (anterior and posterior); and the number of levels fused. It was noted if surgery was circumferential, performed the same day, or staged. For circumferential procedures, total EBL and operative times were calculated. These total EBL and operative times were used in the statistical analysis, because the temporal relationship between transfusions and the staged procedures was not available in the database. Thus, we collected data for EBL and operative times for the entire reconstruction.

Perioperative transfusions were administered at the surgeon's discretion. Intraoperative and postoperative transfusions of PRBCs, both AUTO and ALLO, were recorded as milliliters of blood. In some cases, centers reported the number of units transfused, without blood volume. To account for this, the average value of blood per unit in the cohort was calculated and this value served as a surrogate volume for 1 unit of blood. Transfusion triggers were left to the discretion of the attending surgeon and were not standardized across the cohort. The database was queried for occurrence of complications occurring within the hospital stay and these were classified as major or minor, as well as according to body system.

Descriptive data were compared using the independent sample Student t-test for normally distributed data, Mann-Whitney U-test for non-normally distributed data, and chi-square test for categorical data. Because PABD was not a randomly allocated intervention, matched patient cohorts of PABD and no PABD (NoPABD) were created using propensity weights. Covariates selected were known or reasonable predictors of the need for a perioperative PRBC transfusion. These were age, presence of an osteotomy, number of levels fused, BMI, CCI score, nicotine use, cardiac comorbidities, and EBL. Logistic regression was used to predict PABD and calculate propensity scores. Patients who predonated blood were matched with those who did not, based upon the propensity score with a tolerance of 0.1. A tolerance of 0 means a perfect match and a tolerance of 1 is a random match. Using backward entry (entry at $p = 0.05$, removal at $p = 0.1$), logistic regression was used to evaluate the association between PABD and receipt of any transfusion, as well as the association between PABD and exposure to ALLO blood.

All statistical analysis was performed using SPSS (version 22; IBM). Statistical significance was defined as $p < 0.05$.

Results

Four hundred twenty-eight patients underwent single-stay ASD surgery and were eligible for inclusion. Sixty patients were managed with PABD. Demographic data are shown in Table 1. PABD patients were younger, had a lower BMI, and had fewer medical comorbidities. Surgical data regarding length and magnitude of surgery were similar, including total levels fused (NoPABD mean 9.8 ± 4.0 SD, PABD mean 8.8 ± 4.4 SD, $p = 0.068$). Osteotomies (posterior column/pedicle subtraction/vertebral column resection) were commonly performed and similar between groups. Rates of major and minor perioperative infectious, neurological, cardiopulmonary, renal, and wound-related complications were similar between groups (Table 2). Nearly one-third of PABD patients (30%, 18/60) did not receive

any AUTO blood transfusions, and donated blood was wasted. In 12 of these cases, the patient did not receive any transfusion at all, whereas in 6 cases (10%), AUTO blood was unused and the patient received ALLO blood transfusion. In 15% of cases (9/60), PABD patients were transfused with ALLO blood, in addition to the predonated AUTO blood. Although rates of any transfusion were similar (PABD 70% [42/60], NoPABD 75% [275/368], p = 0.438), NoPABD was associated with a higher risk of exposure to ALLO blood (OR 33.6, 95% CI 11.3–99.8). Rates of perioperative major and minor complications were similar among groups (Major PABD 10% [6/60], NoPABD 12% [43/368], p = 0.537; Minor PABD 30% [18/60], NoPABD 24% [87/368], p = 0.499).

Logistic regression was used to calculate propensity weights for the probability of PABD being performed. Fifty PABD patients were matched using propensity weights to 50 patients who did not predonate blood (Table 3). Ten PABD patients went unmatched and were excluded from further analysis. Age, baseline BMI, baseline CCI score, cardiac comorbidities, number of levels fused, total operative time, and whether an osteotomy was performed were similar. Cell salvage was more common in the PABD group (PABD 87% [52/60], NoPABD 54% [27/50], p < 0.001). Antifibrinolytic use was similar between groups (PABD 50% [30/60], NoPABD 54% [27/50], p = 0.309), although the choice of antifibrinolytic was not similar, with aminocaproic acid used more frequently in NoPABD (20/50) and tranexamic acid used more frequently in PABD (20/30). Patients treated with PABD sustained higher EBL in the propensity-matched cohort (PABD 2311 ± 1467, NoPABD 1393 ± 2445, p < 0.025). When controlling for EBL and cell salvage, regression analyses revealed an association between PABD patients and those receiving any transfusion (OR 15.1, 95% CI 2.1–106.7), indicating that PABD was associated with more frequent transfusions. No relationship was observed between PABD and exposure to ALLO blood, again controlling for EBL and cell salvage. PABD patients were more likely to sustain a major perioperative cardiopulmonary complication (PABD 8/50 [16%], NoPABD 1/50 [2%], p = 0.046). The most common cardiopulmonary complication was minor pleural effusion (PABD 7/50 [14%], NoPABD 0, p = 0.0187). No differences in rates of infection or wound-healing complications were observed (Table 4).

Discussion

Adult spinal deformity surgeries are associated with large volumes of blood loss and, subsequently, often associated with the need for perioperative PRBC transfusion.[13,28] The use of PRBC transfusions is an effort to maintain systemic hemoglobin levels and avoid complication while balancing the risks associated with excessive ALLO PRBC exposure.[18] Surgeons may attempt to avoid the use of ALLO PRBCs, because this is associated with a systemic inflammatory response and may be associated with perioperative infectious complications.[24–26] One method to avoid ALLO blood exposure is PABD. The purpose of this study was to investigate the effectiveness of PABD in adults undergoing surgery for ASD. We sought to examine both the avoidance of ALLO blood exposure and rates of wasted AUTO blood. The effect of PABD on acute, perioperative complications was also examined.

Four hundred twenty-eight patients were identified in this observational, multicenter cohort, with 60 patients (14%) undergoing PABD. Nearly one-third of patients (30%, 18/60) did not receive any autologous transfusion and, subsequently, the donated blood was discarded and wasted. Twelve of these patients received no blood transfusion at all, and 6 patients received blood that was not their donated blood. Overall, 15 patients (15/60, 25%) were exposed to ALLO blood despite PABD. Thus, avoidance of ALLO blood could be considered marginally successful. Regression analyses supported the theory that PABD patients are more likely to receive transfusions (OR 15.1, 2.1–106.7). These findings may be the result of lowered transfusion thresholds for patients with AUTO blood available, because AUTO blood transfusions may be deemed a safer intervention. PABD did not predispose patients to requiring ALLO blood, as has been hypothesized because of iatrogenic anemia. PABD also did not completely protect against ALLO blood exposure, one of the primary goals of PABD. No differences in overall complications were observed. Major cardiopulmonary complications, most commonly pleural effusions, were more common in patients treated with PABD, however. The reason for this association is not readily apparent. Unlike recent reports, exposure to ALLO blood was not associated with acute infectious complications, surgical site or otherwise.

Brookfield et al. found that for short-segment lumbar fusion procedures, PABD did not decrease exposure to ALLO blood and concluded that PABD was unlikely to be an effective intervention in these shorter procedures.[4] Conversely, Solves et al. found that PABD decreased exposure to ALLO blood in a cohort of long-segment (a mean of 10 levels) fusions for spinal deformities, while increasing the probability of some transfusion.[23] Similar to our findings, 18% of patients were exposed to ALLO blood despite PABD, although the volume of ALLO PRBCs transfused was lower with PABD. Wasted PABD with ALLO blood exposure is not uncommon, with rates as high as 40%, and it is probable that laboratory or ordering error plays some role.[6] The fact that PABD may not prevent ALLO blood exposure in adult surgeries is not surprising, particularly in ASD, where mean EBL often approaches 2 liters. In fact, the protective effect of PABD is most pronounced in adolescent idiopathic scoliosis (AIS) surgeries and in shorter lumbar fusion procedures.[4,13,17] As intraoperative blood management measures improve (e.g., use of anti-fibrinolytics and cell salvage), ALLO blood exposure is becoming more infrequent in AIS and the same may soon be the case in degenerative lumbar procedures.[3]

Historically, ALLO blood transfusions have been avoided because of concern related to the transmission of communicable diseases. With newer blood screening techniques, this risk is minimized and should not serve as a barrier to ALLO blood transfusions. More recent work supports an association between the exposure to ALLO blood and perioperative infections. Woods et al. found the volume of ALLO blood transfused was associated with an increased risk of infection in lumbar spine surgeries, suggesting a dose-response effect from ALLO PRBC transfusion.[26] This cohort consisted of lumbar procedures only, however. The immunomodulatory effects of ALLO blood exposure have been confirmed, and further study within the ASD population is needed.[24,25]

A methodical approach to PABD, with patients identified by demographic data and anticipated EBL, is needed. Some patients are unlikely to require any transfusion, whereas

others are likely to require more blood than could be donated preoperatively.[7,13,19] It is possible that ASD surgeries with high EBL are unlikely to benefit from AUTO blood donation, and those cases should be identified in advance.[5,13,29] More frequent transfusions in PABD patients is a common finding, with evidence suggesting that iatrogenic anemia is the cause, compounded by a lower threshold to give AUTO blood in the postoperative period.[12] A large, administrative database study showed PABD to be a risk factor for (i.e., not protective against) exposure to ALLO blood.[27] Unfortunately, as with many retrospective studies similar to the present study, the reasons for transfusion were not recorded. In some cases, PABD may have been performed per a particular surgeon's routine; in others, PABD may have been performed in anticipation of a case involving high blood loss. It seems that PABD is not effective in low and high EBL cases. The true utility of PABD in ASD, if it exists, remains to be shown.

This study is not without limitations. The situation surrounding the decision to perform PABD is not known. Some surgeons may perform PABD routinely, whereas others may use it only when they believe blood requirements will be high. To address this limitation, we created matched cohorts based upon patient factors that may have influenced the decision to perform PABD. The reasons for transfusion of AUTO and ALLO blood are not known. There is no standardized perioperative transfusion protocol in this study group, and what triggers transfusion at one institution may not be observed at another. We used regression techniques, controlling for known and reasonable confounding variables, in an attempt to address this limitation. We do not know why 18 patients did not receive predonated blood. In some cases, when no blood was transfused, the patient may not have manifested symptoms of anemia. In cases where ALLO blood was transfused without AUTO, laboratory or ordering error may have been at fault, emphasizing the inefficiencies associated with PABD.[14] The temporal relationship of any complication and blood transfusion is not known. For the purposes of patient counseling and preoperative decision making, this is less important, as PABD was associated with the complication without implying causality. Finally, our study was underpowered to detect differences in rare occurrences, such as transmission of communicable disease via ALLO blood transfusion or transfusion-associated acute lung injury (TRALI)/transfusion-associated circulatory overload (TACO) related to ALLO, although the rare nature of these events will make them difficult to study in any cohort. A similarly sized study did find a relationship between perioperative transfusions and infection, suggesting that our study was adequately powered for this outcome.[20]

Conclusions

This study supports the concept that PABD may not be effective in ASD, as 25% of patients were exposed to ALLO blood, 30% of cases received no transfusion, and, in a propensity-matched cohort, PABD did not protect against ALLO blood exposure. This is probably due to the large EBL associated with these procedures and the inability of patients to donate a quantity sufficient to protect against transfusions of ALLO blood. Similar to previous work, PABD was imperfect and, not infrequently, donated blood was not given and thus wasted. No differences in perioperative infectious or wound-healing complications existed, as has been previously proposed.[26] As may be expected, patients receiving any transfusion were at

higher risk for perioperative cardiopulmonary complications. Further retrospective studies will probably agree with the literature, which is mixed with respect to results, due in part to recall and performance biases. Studies to date thus offer little evidence to support clinical decision making and patient counseling. The cost-effectiveness of PABD has been questioned, and future studies should include economic data.[9] Prospective studies to determine the clinical and cost-effectiveness of PABD in ASD are required, with attention to PABD timing, reasons for transfusion, and volume of ALLO PRBCs transfused.

ABBREVIATIONS

AIS	adolescent idiopathic scoliosis
ALLO	allogeneic
ASD	adult spinal deformity
AUTO	autologous
BMI	body mass index
CCI	Charlson Comorbidity Index
EBL	estimated blood loss
PABD	preoperative autologous blood donation
PRBC	packed red blood cells

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TABLE 1

Demographic, operative, and perioperative data for PABD and NoPABD cohorts[*]

Variable	NoPABD, n = 368	PABD, n = 60	p Value[†]
Age, yrs	58.4 ± 14.8	48.1 ± 17.3	**<0.001**
Sex			0.188
Female	273 (79.4)	52 (86.7)	
Male	71 (20.6)	8 (13.3)	
Missing/NR	24	0	
BMI, kg/m^2	28.1 ± 8.1	25.1 ± 6.1	**0.002**
CCI score	1.6 ± 1.7	0.7 ± 1.1	**<0.001**
ASA score	2.4 ± 0.6	1.8 ± 0.7	**<0.001**
Nicotine use			0.539
No	304 (90.7)	44 (88)	
Yes	31 (9.3)	6 (12)	
Missing/NR	33	10	
Cardiac comorbidity			**0.006**
No	214 (58.2)	46 (76.7)	
Yes	154 (41.8)	14 (23.3)	
Total levels fused	9.8 ± 4.0	8.8 ± 4.4	0.068
Osteotomy performed			0.660
No	14 (3.8)	3 (5.0)	
Yes	354 (96.2)	57 (95.0)	
Osteotomy type[‡]			
Posterior column	2.8 ± 3.3	1.9 ± 2.7	**0.013**
3-Column	95 (26)	10 (17)	0.127
Total interbody fusions	1.5 ± 1.6	1.5 ± 1.8	0.841
ALIF	32	6	0.742
PLIF	114	9	**0.005**
TLIF	52	4	0.112
XLIF	19	12	**<0.001**
Transsacral	3	9	**<0.001**
Total operative time, min	422.2 ± 205.1	373.4 ± 163.2	0.062
Total EBL, ml	1923.2 ± 1698.8	2198.4 ± 1453.6	0.238
Donated blood, ml	NA	636.8 ± 270.4	
Total AUTO blood transfused, ml[§]	NA	373.4 ± 527.4	

Variable	NoPABD, n = 368	PABD, n = 60	p Value[†]
Total ALLO blood transfused, ml	1045.9 ± 1193.0	166.2 ± 364.5	**<0.001**

ALIF = anterior lumbar interbody fusion; ASA = American Society of Anesthesiologists; NA = not applicable; NR = not recorded; PLIF = posterior lumbar interbody fusion; TLIF = transforaminal lumbar interbody fusion; XLIF = extreme lateral interbody fusion.

[*]
Unless otherwise specified, values are expressed as the mean ± SD or the number of patients (%).

[†]Independent Student t-test for continuous variables except Total EBL (Mann-Whitney U); chi-square test for categorical variables. Values in bold are statistically significant.

[‡]Posterior column osteotomy reported as average levels per case. Three-column osteotomy includes pedicle subtraction, vertebral column resection, and corpectomy.

[§]Excluding intraoperative cell salvage.

TABLE 2

Comparison of perioperative complications between PABD and NoPABD patient cohorts[*]

Category	NoPABD, n = 368	PABD, n = 60	p Value
Infection			0.949
None	341 (92.7)	55 (91.7)	
Minor	14 (3.8)	3 (5.0)	
Major	13 (3.5)	2 (3.3)	
Neurological			0.775
None	342 (92.9)	55 (91.7)	
Minor	19 (5.2)	3 (5.0)	
Major	7 (1.9)	2 (3.3)	
Cardiopulmonary			0.549
None	311 (84.5)	48 (80.0)	
Minor	43 (11.7)	10 (16.7)	
Major	9 (2.5)	2 (3.3)	
Major & minor	5 (1.4)	0 (0)	
Renal			0.719
None	364 (98.9)	60 (100)	
Minor	3 (0.8)	0 (0)	
Major	1 (0.3)	0 (0)	
Wound-healing problems			0.535
None	364 (98.9)	59 (98.3)	
Minor	2 (0.5)	1 (1.7)	
Major	2 (0.5)	0 (0)	

[*] Values are expressed as number of patients (%).

TABLE 3

Demographic, operative, and perioperative data for matched cohorts of PABD and NoPABD patients[*]

Variable	NoPABD (n = 50)	PABD (n = 50)	p Value[†]
Age, yrs	44.4 ± 17.1	48.7 ± 17.6	0.215
Sex			0.358
Female	36 (77)	42 (84)	
Male	11 (23)	8 (16)	
NR	3	0	
BMI, kg/m^2	25.7 ± 6.1	25.4 ± 6.5	0.834
CCI score	0.74 ± 1.2	0.76 ± 1.1	0.931
ASA score	2.0 ± 0.5	1.9 ± 0.7	0.196
Nicotine use			0.766
No	43 (86)	44 (88)	
Yes	7 (14)	6 (12)	
Cardiac comorbidity			0.334
No	41 (82)	37 (74)	
Yes	9 (18)	13 (26)	
Total levels fused	7.8 ± 4.6	9.2 ± 4.1	0.115
Osteotomy performed			0.307
No	1 (2)	3 (6)	
Yes	49 (98)	47 (94)	
Osteotomy type[†]			
Posterior column	1.9 ± 3.0	1.9 ± 2.7	0.869
3-Column osteotomy	3 (6.0)	10 (20)	0.084
Total Interbody Fusions	1.1 ± 1.5	1.4 ± 1.7	0.320
ALIF	11 (22.0)	5 (10.0)	0.102
PLIF	2 (4.0)	6 (12.0)	0.140
TLIF	7 (14.0)	8 (16.0)	0.779
XLIF	7 (14.0)	3 (6.0)	0.182
Transsacral	0 (0)	9 (18.0)	**0.002**
Total operative time, min	364.7 ± 200.4	375.2 ± 161.2	0.773
Total EBL, ml	1393.4 ± 2445.0	2311.6 ± 1467.4	**0.025**
Donated blood, ml	NA	665.2 ± 272.9	
Total AUTO blood transfused, ml[§]	NA	386.6 ± 549.6	

Variable	NoPABD (n = 50)	PABD (n = 50)	p Value[†]
Total ALLO blood transfused, ml	326.5 ± 1220.3	177.5 ± 382.4	0.413

[*]
Unless otherwise specified, values are expressed as the mean ± SD or the number of patients (%).

[†]Independent Student t-test for continuous variables except Total EBL (Mann-Whitney U); chi-square test for categorical variables. Values in bold are statistically significant.

[‡]Posterior column osteotomy reported as average levels per case. Three-column osteotomy includes pedicle subtraction, vertebral column resection, and corpectomy.

[§]Excluding intraoperative cell salvage.

TABLE 4

Comparison of perioperative complications between matched cohorts of PABD and NoPABD patients[*]

Category	NoPABD, n = 50	PABD, n = 50	p Value
Infection			0.766
None	46 (92.0)	46 (92.0)	
Minor	1 (2.0)	2 (4.0)	
Major	3 (6.0)	2 (4.0)	
Neurological			0.489
None	48 (96.0)	45 (90.0)	
Minor	1 (2.0)	2 (4.0)	
Major	1 (2.0)	3 (6.0)	
Cardiopulmonary			0.106
None	47 (94.0)	40 (80.0)	
Minor	2 (4.0)	2 (4.0)	
Major	1 (2.0)	8 (16.0)	**0.046**[†]
Renal			NA
None	50 (100)	50 (100)	
Wound-healing problems			NA
None	50 (100)	50 (100)	

[*] All values are expressed as number of patients (%).

[†] Statistically significant.