

Efficacy of Aprotinin as a Blood Conservation Technique for Adult Deformity Spinal Surgery

A Retrospective Study

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Study Design. A retrospective study that involved a total of 82 adult deformity patients who underwent spinal fusion surgery with instrumentation of 6 or more levels.

Objective. The purpose of this study is to assess the efficacy and safety of aprotinin in reducing blood loss in adult spinal deformity patients.

Summary of Background Data. Aprotinin is an antibrinolytic agent, which has been proven to be effective as a blood-conserving agent in cardiac surgery. This study focused specifically on adult spine deformity patients.

Methods. This retrospective study analyzed a total of 82 adult deformity patients (patients with diagnosis of adult scoliosis and kyphosis) who underwent spinal fusion surgery with instrumentation of 6 or more levels. Forty-one patients who received aprotinin were compared with a control group of 41 patients who did not receive aprotinin. Specific surgical outcome parameters and postoperative complications were assessed.

Results. The average age of the patients was 47 years and 41 years for the aprotinin group and the control group respectively. Thirty-nine percent of cases and 44% of controls had staged anterior/posterior fusion surgery, 39% of cases and 41% of controls underwent single stage posterior fusion surgery and the remaining 27% of cases and 15% of controls had same day anterior and posterior fusion surgery. The average number of levels fused and instrumented was 11.2 for the aprotinin group and 10.7 for the control group. The differences in mean blood loss and blood returned by cell-saver were statistically significantly lower in the aprotinin group (1324 mL vs. 2113 mL; $P = 0.005$ and 390 mL vs. 657 mL; $P = 0.003$). The amount of drainage after surgery was similar (1421 mL vs. 1388 mL; $P = 0.982$). The aprotinin group received an average

of 2.73 units of blood. This was significantly lower than the average 5.02 units that the controls received ($P = 0.003$). The rate of complications was comparable and no allergic reaction to aprotinin was noted. One case exhibited a transitory elevation of blood urea nitrogen/creatinine which resolved before discharge.

Conclusion. The results of our study suggest that the administration of aprotinin is a safe and effective method to reduce blood loss and to decrease the need for transfusions without increasing risk of complication in the younger patients in relatively good general health undergoing spinal deformity surgery requiring 6 or more levels of fusion.

Key words: aprotinin, adult deformity, complications, blood conservation technique, trasylol, blood loss, scoliosis, spine surgery, transfusion. **Spine 2008;33:1775–1781**

Blood loss in spine surgery is often significant and can lead to increased morbidity and mortality, especially in the adult deformity patient (types of adult deformity: scoliosis, kyphosis, and sagittal imbalance). The need for transfusions is common and has multiple possible complications. Infections such as hepatitis B (estimated risk 1/63,000 units transfused), hepatitis C (estimated risk 1/1.6 million units transfused), human immunodeficiency virus (HIV-estimated risk 1/1.9 million units transfused), and cytomegalovirus can be transmitted from an infected donor.¹ Immune and allergic reactions can also occur resulting in anaphylactic shock (estimated risk 1/150,000 units transfused) or acute hemolysis (estimated risk 1/21,000 units to 1/250,000 units).¹ In addition, a possibility of blood shortage always exists and many patients today refuse transfusions for religious reasons or otherwise.

To avoid or decrease the amount of transfusions, other blood conservation approaches have been used. Preoperative blood donation has received increasing emphasis as has the administration of erythropoietin before surgery. However, not all patients are candidates to donate blood before surgery because of pre-existing anemia or the presence of underlying medical conditions. Hypotensive anesthesia is also a method employed to reduce blood loss. The anesthesiologist and surgeon must be wary of possible complications resulting from end organ hypoxia such as kidney and spinal cord injury. Blood recycling through a cell saver system has become standard during long segment spinal fusion procedures, further improving surgical care. Finally, proper positioning

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The drug, Aprotinin (Trasylol®, Bayer, West Haven, CT) that is the subject of this manuscript is not FDA approved for Spine Surgery but it is commercially available in the United States. The drug is FDA approved and has been effectively used to reduce perioperative blood loss and the need for transfusion in patients undergoing cardiopulmonary bypass in the course of coronary artery bypass graft surgery. There is no ongoing FDA-approved investigation protocol to evaluate the effectiveness and safety of Aprotinin use in spinal surgery.

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with the abdomen free on a Jackson table is paramount as is maintaining meticulous hemostasis by the surgeon.

Antifibrinolytic agents have been found to effectively reduce blood loss in coronary artery bypass surgery and in certain orthopedic surgeries.^{2–10} Specifically, aprotinin (Trasylol, Bayer), a serine protease inhibitor, decreases bleeding by acting on the coagulation cascade, antifibrinolytic pathway, inflammatory response, and on the platelet membrane.^{11–13} Many studies show that aprotinin effectively reduces blood loss in spine surgery.^{14–18} This study has examined specifically the adult spine deformity patient. This group of patients is different than other surgical patients in that they have more medical problems, larger and more rigid curves, and may require anterior-posterior or staged surgeries involving extensive work on bone. In these patients, massive blood loss is a real concern even when using standard blood conservation techniques and must be addressed aggressively in order to avoid complications. The purpose of this study is to assess the efficacy of aprotinin in reducing blood loss in adult spine deformity patients requiring 6 or more levels of fusion or instrumentation.

Materials and Methods

We conducted a retrospective study reviewing hospital charts from 82 spinal deformity patients who underwent fusion surgery and instrumentation of 6 or more levels. The patients were operated on by the 4 surgeons in the group at the Spine Institute. Only patients 18 years old and older were included in the study. The 41 patients who received aprotinin from January 2003 to July 2005 were compared with 41 historical controls. The list of the patients who had received aprotinin from January 2003 to June 2006 was obtained from the pharmacy database. Seventy-four patients received aprotinin in this period. Forty two patients fulfilled the inclusion criteria in the study. One patient was excluded because there was no record that patient received aprotinin in the hospital chart. Aprotinin was used in surgeries with massive estimated blood loss: in staged reconstructive surgeries, and 6 or more level fusion surgery. All patients receiving aprotinin signed an informed consent and were explained the risks and benefits of the drug. The controls consisted of a random sample of 41 patients fulfilling our inclusion criteria and operated from June 2000 and December 2002, at a time when aprotinin was not available at our institution. In these patients, the surgical technique and materials used were the same as our aprotinin population with the only difference being aprotinin administration. The controls were retrieved from Spine Institute registry of operated patients. We generated a randomization table using SPSS 12 software and from the 69 patients that were compiled from the registry and patients' office charts. Our target was to have the same number of controls as cases, and 41 patients were randomly selected from this table. Our power analysis showed that 41 patients per group were required (we considered a difference in mean blood loss of at least 500 mL between the 2 groups clinically relevant and set up α at 0.05 with 80% power). In the control group, in a multistaged operation we considered the stage that would have received aprotinin, had the drug already existed.

We collected demographic data, *e.g.*, age, gender, data on medical history and diagnosis, surgical data, and data on known risk factors that might influence the outcomes. The

Table 1. Descriptive Data

Variable	Cases (n = 41)	Controls (n = 41)	P
Demographics			
Mean age (yrs)	47 (19–70), SD: 15	41 (18–69), SD: 15	0.07
Gender (women)	33 (81%)	32 (78%)	0.785
Jehovah's witnesses	2 (5%)	1 (2%)	1
Diagnoses			
Scoliosis	35 (85%)	34 (83%)	0.762
Kyphosis	14 (34%)	7 (17%)	0.077
Flat back syndrome	3 (7.3%)	3 (7.3%)	1
Revision case	6 (15%)	5 (12%)	0.746

outcomes of interest were estimated blood loss (as reported by the anesthesiologist), amount of drainage, transfusions, the use of cell saver, and perioperative and postoperative complications.

The normality of the distribution of continuous variables was tested using Kolmogorov-Smirnov and Shapiro-Wilk test and histogram and Normal Q-Q plots. Normally distributed continuous variables, namely, the length of surgery, the amount of cell saver, patient weight, and certain laboratory results were analyzed using *t* tests. Nonparametric tests were used for the other continuous variables that were not normally distributed even after transformation. Categorical data were analyzed using the Pearson χ^2 test, the Fisher exact test, the Fischer-Freeman-Halton test or the Cochran-Armitage test. We excluded patients with a subsequent operation during the hospitalization in the analysis of the amount of drainage, the length of stay in the intensive care unit, and the overall length of stay. Exclusion of these patients (1 patient from control group and 2 from case group) did not affect the results of main outcome variables.

We created 2 regression models to test whether the regimen used influenced the outcome and to test if the association between the use aprotinin and the blood loss depended on the number of levels fused or instrumented.

Results

A descriptive analysis (Table 1) shows that the case and control groups are comparable in terms of age, gender, and diagnoses. The majority of the patients are women (81% of the cases and 78% of the controls) and the mean

Table 2. Descriptive Surgery Data

Variable	Cases (n = 41)	Controls (n = 41)	P
Surgery			0.688
2 staged procedure	16 (39%)	18 (44%)	
1 stage procedure	9 (22%)	6 (15%)	
Posterior fusion (not staged)	16 (39%)	17 (41%)	
Mean no. levels fused and instrumented	11.2 (6–17), SD: 2.72	10.7 (6–17), SD: 2.63	0.384
Surgeons – No. surgeries			0.426
Surgeon – 1	6 (15%)	6 (15%)	
Surgeon – 2	7 (17%)	10 (24%)	
Surgeon – 3	12 (29%)	6 (15%)	
Surgeon – 4	16 (39%)	19 (46%)	

Table 3. Regimen of Aprotinin Used (n = 32 Patients in the Aprotinin Group)

Regimen	No. Patients	Loading Dose (KIU)	Maintenance Dose (KIU/hr)
1	17	2 mio	0.5 mio
2	5	4 mio	1 mio
3	4	1 mio	0.5 mio
4	2	2 mio	0.75 mio
5	2	2 mio	1 mio
6	1	0.6 mio	0.4 mio
7	1	2 mio	2 mio

ages are similar (mean age of 47 in the case group and 41 in the control group). The majority of the patients suffer from scoliosis (85% in the aprotinin group and 83% in the control group). Kyphosis tends to be more frequent in the case group, but the difference is not statistically significant.

The surgical procedures performed in both group are comparable (Table 2). About 15% of the cases and 12% of the controls had revision surgery. Thirty-nine percent of cases and 44% of controls had staged anterior/posterior fusion surgery, 39% of cases and 41% of controls underwent single stage posterior fusion surgery, and the remaining 27% of cases and 15% of controls had same day anterior and posterior fusion surgery. Average osteotomies were significantly higher in the case group (1.2 ± 2.1) than in control group (0.1 ± 0.3). The mean number of levels fused and instrumented is 11.2 and 10.7 in the case and control groups, respectively. Topical thrombostatic agents including surgifoam and gelfaom were used in both aprotinin and nonaprotinin cases at the surgeons' discretion.

Aprotinin was administered using several different regimens (Table 3). The most common one being the

administration of a test dose of 10,000 kallikrein inhibitory unit (KIU), a loading dose of 2-million KIU administered over 20 to 30 minutes, and a maintenance dose of 0.5 million KIU per hour. In 8 cases, the regimen used is not reported in the chart. These patients received aprotinin according to the pharmacy records and hospital charts, however, the exact regimen was not documented. Based on recorded total dose of aprotinin administered on these 8 patients and length of the surgery, we assumed that these 8 patients received the directed dosage (standard dosage that is most commonly used).

Table 4 reports data on medical history and other potential confounding or mediating factors and shows that the control group tends to be healthier than the case group. In particular, heart diseases, hypertension, and a history of thrombotic events are more frequently reported. Although, those factors may influence the surgical outcome, they do not influence any of the outcomes in our models. Other factors that might influence blood loss and surgical outcome such as the weight and the ASA classification are comparable between the 2 groups (Table 4).

As reported in Table 5, the estimated blood loss is significantly lower in the aprotinin group. Indeed, the administration of aprotinin is associated with a 40% decrease in blood loss. The numbers of units transfused before surgery and during the entire stay are significantly lower in the aprotinin group (Table 5). The administration of aprotinin is associated with an approximate 50% decreases in the number of units transfused (both perioperatively and in total). The amount of cell saver reinfused is also significantly lower in the aprotinin group (Table 5). The amount of postoperative drainage is comparable in both groups, which goes against the perception that many spine surgeons have that aprotinin is linked with a large amount of postoperative drainage

Table 4. Patients' Medical History, Mean Weight, ASA Scores and Laboratory Test Results

Variable	Cases	Controls	P
ASA scores (No. patients)*			0.18
1 (No. patients)	3	5	
2 (No. patients)	23	27	
3 (No. patients)	14	9	
Medical history			
Heart diseases	8 (19%)	5 (12%)	0.211
Bleeding disorders	0	0	No difference
History of thrombotic events	5 (12%)	0	0.055
Hematologic disorders	6 (15%)	2 (5%)	0.264
Cerebral palsy	0	1 (2.4%)	1
Neuromuscular disorders	2 (5%)	1 (2.4%)	1
Encephalopathy	0	0	1
Meningocele	0	0	1
Mean weight (lbs)	149 (82–230), SD: 32	138 (60–214), SD: 33	0.084
Laboratory tests			
Preoperative hemoglobin (g/dL)†	12.5 (9–17), SD: 2.2	11.5 (9–15.7), SD: 1.8	0.045
Last postoperative hemoglobin (g/dL)*	10.3 (7.8–13.7), SD: 1.4	10.1 (8.1–12.6), SD: 1.1	0.588
Preoperative hematocrit (%)‡	36.4 (27–45), SD: 6	34.5 (27.4–44), SD: 4.9	0.137
Last postoperative hematocrit (%)*	30.5 (24–40), SD: 4	29.7 (24–36.7), SD: 3.4	0.301

*Data missing for 1 patient in the aprotinin group.

†Data missing for 1 case and 2 controls.

‡Data missing for 1 case and 1 control.

Table 5. Efficacy

Variable	Cases	Controls	P
Efficacy			
Mean estimated blood loss (ml)	1324 (120–3000), SD: 608	2113 (500–6000), SD: 1296	0.005
Mean estimated blood loss per pounds of body weight (ml)	9.1 (0.9–22.6), SD: 4.4	16.7 (3.4–66.7), SD: 13.5	0.001
Mean estimated blood loss per levels fused or instrumented (ml)	118 (17–225), SD: 47	196 (63–500), SD: 116.3	0.002
Mean cell saver (amount returned) (ml)	390 (125–875), SD: 199	657 (0–2000), SD: 457	0.003
Mean amount of drainage (ml)*	1421 (0–4425), SD: 1037	1388 (40–4375), SD: 935	0.982
Mean length of surgery (hh:mm)**	7:33 (4:30–12:15), SD: 1:35	6:30 (2:50–9:35), SD: 1:42	0.005
Mean length of stay (d)†	9.3 (1–21), SD: 3.49	8.4 (4–22), SD: 3.15	0.187
Mean no. days in ICU (d)‡	1.9 (1–7), SD: 1.59	1.7 (0–7), SD: 1.52	0.586
Mean no. units transfused	2.73 (0–9), SD: 2.45	5.02 (0–18), SD: 4.02	0.003

*35 cases and 37 controls included in analysis (2 cases and 1 control were excluded because they did not have any drain inserted; the amount of drainage could not be assessed in 3 cases and 2 controls because of missing documents or because the patients had a subsequent operation after the operation considered.

†Data missing for 1 case.

‡1 case and 2 controls excluded for this analysis because they had a subsequent operation.

(rebound effect). The length of stay in the intensive care unit and the length of the hospitalization are not statistically significantly different, although the stays tend to be shorter in the control group. The length of the operation is significantly lower in the control group than the case group, with a mean length of 7.55 hours and 6.5 hours, respectively. Table 6 shows the data of estimated blood loss by each surgeon. Surgeon number 3 had the most significant drop in estimated blood loss (EBL) in the case group. He had done twice as many aprotinin cases as controls, however, excluding him from the study did not significantly affect the results of the main outcome, blood loss.

As reported in Table 7, the numbers of complications are similar in both groups. A list of the complications is reported in Table 8. Two patients in the case group suffered from symptomatic deep venous thrombosis (DVT) after surgery. Three patients in the case group needed to be reoperated, the reasons being a wound infection, a broken drain, and an iatrogenic anterior defect. One patient in the control group needed to be reoperated for a wound infection. The occurrences of infection are similar in both groups. The wound infections, in both case and control groups, were reoperated after 9 days of initial surgery. One patient in the aprotinin group experienced a transitory elevation in creatinine/blood urea nitrogen (BUN) with a peak at day 4 (highest creatinine measure at 1.3 and highest BUN measure at 39). Both values returned to normal by discharge. Laboratory results (Table 3) are comparable between the 2 groups except for the preoperative hemoglobin, which is statistically significantly higher in the aprotinin group (12.5% *vs.* 11.5% in the aprotinin and control groups, respectively). In the

control group, slightly higher percent of patients autodonated before surgery (not statistically significant) were compared with patients in the aprotinin group (59.5% and 40.5% autodonated in control and case groups, respectively). This might explain the difference in hemoglobin levels before surgery between the groups; however, the difference in hemoglobin does not explain the differences in outcomes between the 2 groups.

A regression model shows that the beneficial effect of aprotinin is similar regardless of which level was fused or instrumented. Another model shows that the regimen of aprotinin used does not influence the estimated blood loss. The last model may lack power given the number of different regimens used.

■ Discussion

It has been established that major orthopedic surgery is associated with an increased amount of blood loss resulting in an increased need for blood transfusions. Antifibrinolytic agents like aprotinin have been associated with lower blood loss and decreased fibrinolysis during the perioperative period in cardiac surgical patients.^{19,20} It has also been shown to reduce blood loss in major orthopedic surgeries.^{3–10} Thus far, there has not been a study to assess the efficacy of aprotinin in reducing blood loss in the adult spine deformity patient requiring long segment spinal fusion. In our retrospective study, the administration of aprotinin significantly decreased blood loss and the need for transfusion in an adult deformity population requiring 6 or more levels of fusion or instrumentation.

This study, although by no means the first study to examine the effect of aprotinin in spine surgery patients,

Table 6. Estimated Blood Loss by Surgeons

Variable	Cases (Mean and Range)	Controls (Mean and Range)
Surgeons		
Surgeon no. 1	2025 mL (1150–3000), SD: 735	2567 mL (1300–4000), SD: 1001.33
Surgeon no. 2	1285 mL (700–2500), SD: 609	1545 mL (500–4000), SD: 1329
Surgeon no. 3	995.8 mL (400–1850), SD: 398	1667 mL (800–3000), SD: 789
Surgeon no. 4	1323 mL (120–2250), SD: 508	2410.5 mL (600–6000), SD: 1410

Table 7. Safety

Variable	Cases	Controls	P
Safety (complications)			
Major renal disorders (%)	0	0	No difference
Major cardiac disorders (%)	0	0	No difference
Stroke (%)	0	0	No difference
DVT (%)	4.9	0	0.494
Reoperation (%)	7.3	2.4	0.616
Allergic reaction to aprotinin (%)	0	N/A	N/A

is consistent with the results of previous spine surgery literature. Cole *et al*¹⁷ compared the effect of aprotinin in children undergoing long segment posterior spinal fusion. In that study, aprotinin was found to decrease blood loss and transfusions in a group of pediatric and adolescent scoliosis patients who were deemed at higher risk for intraoperative bleeding. Urban *et al*¹⁵ studied adult patients treated with complex anterior and posterior reconstruction and fusion. The group receiving aprotinin exhibited significantly less blood loss and transfusion requirements than the control group. Lentschener *et al*¹⁴ published a study on adult patients undergoing posterior lumbar interbody fusion. Aprotinin treatment resulted in a significant decrease in the total perioperative blood loss and the first 24 hour postoperative blood loss when compared to the placebo-treated controls.

Our control group and aprotinin group were randomly selected from adult deformity patients requiring 6 or more levels of fusion and instrumentation. These groups matched with regards to spine segments fused, type of surgeries done, age, gender, weight, and preoperative diagnosis. However, the length of surgery was found to be longer in the aprotinin group. The most likely explanation for the longer surgical time is that aprotinin may have been administered in cases where the

surgery was thought to be more complex by the operating surgeon. This has also presented selection bias as follows: in the aprotinin group more osteotomies were done compared to the control group, and the aprotinin group was less healthy overall and had more comorbidities than the controls. The comorbidities included heart disease, hypertension, and a history of thrombotic events. However, despite the selection bias presented: the longer surgical time, more complex surgical procedures, and increased comorbidities, which generally tend to increase blood loss, we observed a decrease in blood loss in the aprotinin group.

In our analysis we found that in the 2 groups, the number of complications were similar. A potential concern with antifibrinolytic agents, such as aprotinin, is an increase in thrombotic events. However, aprotinin also has anti-inflammatory and potentially antithrombotic effects. Studies, such as that of Murkin, have documented the ability of aprotinin to suppress platelet aggregation and decrease the activity of intrinsic pathway coagulation factors, leading to decreased thrombotic events.²¹ Furthermore, Haas found no association between the prevalence of DVT and the administration of aprotinin.²²

At Beth Israel Medical Center, each service has its own DVT prophylaxis protocol; in our service, every surgery patient gets TED stockings and sequential compression devices. Early mobilization is encouraged. If a patient is slow with therapy and ambulation patient is typically started on Heparin 5000 units Sub-Q BID, occasionally TID depending on the size of the patient. Even so, 2 patients in our aprotinin group did experience symptomatic DVT's, although this was not statistically significant. One explanation may be that there was a higher number of patients with a history of thromboembolic events in the case group and could be explained by the fact that a history of thrombotic event was more often reported in the group of patients who received aprotinin. Also, although a rare occurrence, there were no allergic reactions noted. Anaphylactic reactions can only occur in patients who have been sensitized to aprotinin through prior exposures. These allergic reactions can easily be avoided by giving a test dose. Finally, there is a perception by many spine surgeons that aprotinin leads to increased postoperative drainage, potentially leading to more blood transfusions. Our study did not show any increase in postoperative drainage in our aprotinin group compared to the control.

Recently, it has also been espoused that the use of aprotinin in patients undergoing coronary artery bypass graft surgery has led to serious end organ damage. Specifically, the risk of renal failure was doubled, the risk of myocardial infarction was increased by 55%, and there was a 181% increase in the risk of stroke or encephalopathy.²³ Similarly, Okubadejo *et al* showed an increased risk of renal failure in the aprotinin group compared to the placebo group.²⁴ However, in our study, there was

Table 8. List of Adverse Events

Type of Complications	Cases	Controls
Cardiovascular	Unexplained tachycardia 2×	None
Renal	Transitory slight elevation of renal tests postoperatively 1×	None
Hematological	DVT 2×	Coagulopathy after acute blood loss (with prolonged intubation) 1×
	Hematoma 1×	Anemia 2nd to acute blood loss 1×
	Anemia 2nd to acute blood loss 1×	
Infectious	Wound infection 1×	Wound infection 1×
	Other infections 3×	Other infections 3×
Neurological	Exacerbation of multiple sclerosis 1×	Postop aphasia and confusion 1×
Surgical	Iatrogenic large defect 1×	None
	Broken drain 1×	
	Dural leak 1×	
Other	Allergic reaction to OxyIR 1×	None

only 1 patient who exhibited a transient elevation in BUN/creatinine. This patient did not require dialysis and the BUN/creatinine had returned to normal by discharge. No patients had a stroke or myocardial infarction. Thus, in our group of patients undergoing long segment posterior spinal fusion, there was no increased risk of end organ damage nor was there an increase in complications in general.

The differences in the characteristics of the study population being examined might be the reason for the conflicting results between these studies. For example, patients in our study were in an overall better state of health than the group of patients undergoing cardiac surgery in Mangano's study. Furthermore, the patients in our study sample were much younger than the patients in Okubadejo's study (47 years and 41 years for the aprotinin group and the control group respectively *vs.* 50.9 years and 50 years for the aprotinin group and the placebo group respectively). Finally, in Okubadejo's study, the patients with renal failure complications were older (ages 61 to 73 years old) and possessed various significant comorbidities.

Another reason for the inconsistency in the results between these studies might also be the difference in how aggressively the mean arterial blood pressure was dropped during the surgeries. The mean arterial blood pressure did not drop below 60 mmHg during surgery for most of our patients. Perhaps the hypotension was more strictly monitored during the surgeries in our study population as compared to the other studies. Extended periods of hypotension during surgery could lead to significant end organ damage.

There also remains another plausible explanation for the increased risk of developing renal failure in patients undergoing complex adult deformity spine surgery. Aprotinin possesses a high affinity for renal tissue and also has a prolonged binding time. Thus, the molecular characteristics of aprotinin itself combined with a compromised renal system caused by either disease or prolonged hypotension during surgery might increase the risk of developing renal failure in the adult spine deformity patient.

In conclusion, the administration of aprotinin resulted in a 40% decrease in blood loss and a 50% decrease in the number of transfusions in our group of adult spine deformity patients requiring 6 or more levels of fusion or instrumentation. There was no increased risk of complications and no allergic reactions were noted. Thus, our study results suggest that in adult deformity patients undergoing fusion procedures requiring 6 or more levels, the administration of aprotinin is a safe and effective method to reduce blood loss and to decrease the need for transfusions without increasing risk of complication in relatively young and healthy patient population. However, further larger studies are warranted to evaluate the use of

aprotinin in older patients undergoing fusion procedures requiring 6 or more levels.

■ Key Points

- The administration of aprotinin appears to be an effective method to reduce blood loss and to decrease the need for transfusions without increasing risk of complication in patients undergoing spinal deformity surgery requiring 6 or more levels of fusion or instrumentation.
- Our study suggests that there is no increase in postoperative drain output or rebound blood loss.
- The administration of aprotinin appears to be a safe method to use in younger patients in relatively good general health undergoing spinal deformity surgery requiring 6 or more levels of fusion or instrumentation.
- Additional larger studies are needed to further evaluate the safety of the aprotinin in older patients undergoing spinal deformity surgery.

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