

Abdominal aortic calcification is an independent predictor of perioperative blood loss in posterior spinal fusion surgery

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INTRODUCTION: The posterior approach in spinal fusion surgery is associated with substantial blood loss, which can complicate the perioperative course, necessitate blood transfusion and worsen postoperative outcome. Determining risk factors for blood loss can help to optimize perioperative patient blood management. Abdominal aortic calcification (AAC) is regarded as a marker of advanced atherosclerotic vascular disease and has gained attention in spinal surgery due to its association with degenerative disc disease, decreased vertebral bone mineral density and sarcopenia. Although AAC has been shown to correlate with postoperative morbidity while also altering cardiovascular hemodynamics, its effect on blood loss remains unexplored. Therefore, this study aimed to analyze the impact of AAC on perioperative blood loss in posterior spinal fusion (PSF) surgery.

METHODS: We retrospectively analyzed a cohort of patients diagnosed with degenerative lumbar spinal conditions who underwent single or multilevel PSF between March 2016 and July 2023. Total blood volume (TBV) and estimated blood loss (EBL) were calculated via established formulae. AAC was assessed on lateral lumbar radiographs according to the Kauppila classification by measuring the calcification of the anterior and posterior aortic wall at the L1 to L4 vertebral levels. Patients were categorized into the no AAC (AAC = 0) and AAC groups (AAC ≥ 1). Predictors of the EBL to TBV ratio were examined via univariable and multivariable regression analyses, controlling for age, sex, body mass index, multilevel fusion, surgery duration, tranexamic acid (TXA), osteopenia/osteoporosis, hypertension, diabetes, smoking history, preoperative daily aspirin intake, and AAC. The statistical significance level was set as $p < 0.05$.

RESULTS: A total of 199 patients (47.2% female) with a median age of 65 years (IQR 57 – 72) and a median BMI of 29.4 kg/m² (IQR 26.4 – 32.7) met inclusion criteria and were analyzed. AAC was present in 106 patients (53.3%). The AAC group consisted of an older cohort compared to the No AAC group ($p < 0.001$), with a higher rate of hypertension ($p < 0.001$), diabetes ($p = 0.005$), positive smoking history ($p < 0.001$), osteopenia or osteoporosis ($p < 0.001$), and daily aspirin use ($p = 0.004$). Also, more patients in the AAC group received intravenous TXA intraoperatively compared to the No AAC group ($p < 0.001$). The groups did not differ in surgical parameters such as multilevel fusion and surgery duration. After adjustment for all confounders, AAC was independently associated with the EBL to TBV ratio, accounting for an increase in blood loss of 4.65% of TBV (95% CI: 1.29 – 8.00, $p = 0.007$). Furthermore, female sex ($p < 0.001$), multilevel fusion ($p < 0.001$), and surgery duration ($p < 0.001$) were identified as additional independent positive predictors for the EBL to TBV ratio. Only TXA administration negatively predicted the EBL to TBV ratio ($p < 0.001$).

DISCUSSION: This is the first study to identify AAC as an independent risk factor of perioperative blood loss in PSF surgery. The AAC group comprised an older cohort with a higher rate of comorbidities. This was expected due to the established correlations of AAC with age and various conditions such as hypertension, osteoporosis and cardiovascular disease. The lower rate of TXA administration in the AAC group can be explained by the concern for elevated risk of thromboembolic and/or cardiac events in this cohort. AAC remained a significant predictor of blood loss after adjustment for the comorbidities and TXA. Our study was limited by the inter-group differences, limited generalizability as it was conducted in a single center, and by possible unknown confounders not accounted for in the analysis.

SIGNIFICANCE/CLINICAL RELEVANCE: In addition to its link to degenerative spinal conditions and adverse postoperative outcomes, the relationship between AAC and increased blood loss warrants attention in adults undergoing PSF. Further studies are required to confirm and explore this causal relationship.

Table 1: Linear Regression Analysis for the EBL to TBV Ratio

Variables	Univariable linear regression analysis		Multivariable linear regression analysis	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Age	0.37 (0.22 – 0.52)	<0.001*	0.07 (-0.08 – 0.22)	0.375
Female Sex	5.71 (2.19 – 9.23)	0.002*	6.73 (3.72 – 9.75)	<0.001*
BMI (kg/m ²)	-0.10 (-0.44 – 0.24)	0.548	-0.12 (-0.40 – 0.15)	0.388
Multilevel fusion	10.42 (7.04 – 13.79)	<0.001*	6.64 (3.47 – 9.81)	<0.001*
Surgery duration (min)	0.08 (0.05 – 0.10)	<0.001*	0.07 (0.05 – 0.10)	<0.001*
Tranexamic acid	-8.58 (-12.13 – -5.04)	<0.001*	-7.69 (-10.76 – -4.61)	<0.001*
Osteopenia/Osteoporosis	3.06 (-0.71 – 6.82)	0.111	-1.81 (-5.00 – 1.37)	0.263
Hypertension	5.04 (1.50 – 8.59)	0.006*	-0.24 (-3.45 – 2.97)	0.883
Type 2 DM	1.85 (-3.59 – 7.29)	0.503	-4.36 (-8.87 – 0.15)	0.058
Smoking history	4.60 (0.99 – 8.21)	0.013*	1.23 (-1.74 – 4.21)	0.415
Daily aspirin use (81mg)	3.68 (-0.60 – 7.97)	0.091	3.52 (-0.03 – 7.06)	0.052
AAC	6.77 (3.28 – 10.26)	<0.001*	4.65 (1.29 – 8.00)	0.007*

EBL = Estimated blood loss accounting for intra- and post-operative blood loss, TBV = Total blood volume, ASA = American Society of Anesthesiologists, DM = Diabetes mellitus, AAC = Abdominal aortic calcification, *Significant.