Association between the Surgical Apgar Score and Perioperative Complications after Radical Prostatectomy

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Key Words

Prostate cancer · Prostatectomy · Postoperative complications · Postoperative care

Abstract

Objective: To evaluate whether the Surgical Apgar Score (SAS) can identify patients who are at risk for perioperative adverse events (PAE) following radical prostatectomy for prostate cancer. **Patients and Methods:** At a single academic institution, 994 patients undergoing radical prostatectomy between 2010 and 2013 were analyzed retrospectively. The SAS was calculated from anesthesia records, evaluated to predict PAE within a 30-day time period postoperatively; these events were classified according to standardized classification systems. **Results:** We observed adverse events in 45.4% (451/994) of patients with a total of 694 events. Overall, 41% (408/994) had low- and 9.9% (98/994) had high-grade events. A lower SAS was identified as an independent predictor of any ($p < 0.001$) and low-grade adverse events ($p = 0.001$) for those patients who had undergone open retropubic radical prostatectomy (ORRP). Each 1-point increment resulted in a 24% decrease in the odds of any (95% CI 0.66–0.88) and a 21% decrease in the odds of a low-grade (95% CI 0.69–0.91) event. Adverse events of robot-assisted

prostatectomy were not associated with the SAS. **Conclusions:** Lower SAS values indicate patients at risk for adverse events after ORRP. The SAS might serve as one variable for outcome assessment, reflecting the challenge of mutual surgical and anesthesiology procedure management.

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Introduction

Radical prostatectomy is a standard treatment for localized prostate cancer (PCA). Applying a standardized reporting methodology, like the modified Clavien–Dindo classification (CDC) [1], it is found that the overall complication rate of the procedure can be as high as 42.5% [2]. Easily applicable objective models that evaluate the postoperative risk of morbidity and mortality of radical prostatectomy are rare. Established risk factors for complications are age, body-mass-index, and a pelvic lymphadenectomy [3, 4]. Recently the Surgical Apgar Score (SAS) [5, 6], calculated of predetermined point values assigned to intraoperative estimated blood loss, lowest heart rate (LHR) and lowest mean arterial pressure (MAP; table 1) was published. The SAS ranges from 0 to 10 with lower SAS scores indicating an adverse postop-

Table 1. Calculation of the 10-point SAS*, 5

	SAS, number of points				
	0	1	2	3	4
Estimated blood loss, ml	>1,000	601–1,000	101–600	≤100	
Lowest mean arterial pressure, mm Hg	<40	40–54	55–69	≥70	
Lowest heart rate/min	>85 [†]	76–85	66–75	56–65	≤55 [†]

* The SAS was calculated from the time of incision to the time of wound closure, from the estimated blood loss, lowest mean arterial pressure, and lowest heart rate entered in the anesthesia protocol during the operation. The score is the sum of the points from each category.

[†] Occurrence of pathologic bradyarrhythmia, including sinus arrest, atrioventricular block or dissection, junctional or ventricular escape rhythms, and asystole also received 0 points for the lowest heart rate.

erative outcome [5, 6]. Only a few publications investigated the applicability of the SAS to predict morbidity and mortality of urologic surgical procedures. Ito et al. [7] demonstrated that patients who underwent renal mass excision were 3.7 times more likely to experience a major complication when the SAS was lower than 4, and 24 times more likely to die within 90 days of surgery as compared to those with a SAS ≥8. In patients who underwent radical cystectomy Prasad et al. [8] showed a progressive decrease in complications with increasing SAS. We sought to evaluate the practicability of the SAS to predict perioperative adverse events (PAE) of robot-assisted laparoscopic transperitoneal radical prostatectomy (RARP) and open retropubic radical prostatectomy (ORRP) within 30 days of surgery.

Patients and Methods

After receiving the approval of the Ruhr-University Bochum Ethics Committee (5084-14), PAE in all patients scheduled for radical prostatectomy between September 2010 and March 2013 at a single-university center were retrospectively collected from patient files including the surgeons note, anesthesia protocol and outpatient records. All intraoperative adverse events were graded according to the Satava approach [9] and pre- and postoperative adverse events were classified according to the CDC [1]. Pre-, intra- and postoperative adverse events were combined to PAE and grouped in any (CDC1–5), low- (CDC1–2) and high-grade (CDC3–5) events, respectively. All available PAE within 30 days of postoperation were included. In patients with multiple PAE, only the highest grade was used for statistical analyses. The SAS was calculated as described previously [5, 6] (table 1) from the anesthesia records and the surgical report. The variables for SAS were collected after anesthesia induction from incision to wound closure. Patients with lower scores are considered to be at a higher risk for adverse outcomes [5, 6]. The surgical approach used (RARP or ORRP) was subjectively decided by patients and surgeons. RARP was performed as described by Menon et al. [10] with minor modifications made by

a single surgeon and ORRP was performed as described by Budäus et al. [11], with minor modifications made by 4 different surgeons of whom 3 had the experience of having performed more than 500 previous procedures. In the absence of contraindications, anesthesia administered for RARP and ORRP was performed using a combined anesthesia technique. A lumbar epidural catheter for intra- and postoperative analgesia was placed and an effective dose of 10 ml Bupivacaine 0.5% administered, which was repeated every 2 h. General anesthesia was induced with fentanyl, propofol and rocuronium. The patient was then intubated. Anesthesia was maintained by applying desflurane. No specific intraoperative fluid management regime was preferred during the study period. Uni- and multivariable binominal logistic regression analyses were used to identify the association between assumed and previously described risk factors for PAE. The analyses were performed for patients who underwent ORRP and RARP, separately. The SAS was included in the models as continuous variable, assuming a linear relationship between the score and the odds of a PAE. As the SAS is driven by blood loss, a sensitivity analysis was performed excluding cases with perioperative blood transfusion. Additionally, specific complications as shown in table 2 were evaluated. All statistical analyses were performed using SPSS 23 (IBM Corporation, Armonk, N.Y., USA). A $p < 0.05$ was considered statistically significant.

Results

During the study period, $n = 1,006$ radical prostatectomies were performed. A complete set of anesthesia records was available for 98.8% (994/1,006). These patients resembled the study population. Clinical and histopathological parameters of the patient collective are shown in table 3.

Results of the ORRP Population

A total of 609 PAE was observed in 775 patients. Of those, 99.7% (607/609) occurred postoperatively. Of 9 intraoperative PAE, 44.4% (4/9) were Satava grade I and 55.6% (5/9) Satava grade II. Satava grade II events were ureteral lesions ($n = 2$), rectal laceration ($n = 1$), bladder

Table 2. Association of the SAS with specific complications in patients undergoing ORRP and RARP

	Open (n = 775)				Robotic (n = 219)			
	n (%)	OR	95% CI	p value	n (%)	OR	95% CI	p value
Cardiopulmonal ^a	58 (7.5)	1.00	0.79–1.27	0.998	17 (7.8)	1.06	0.66–1.69	0.812
Thrombembolic ^b	16 (2.1)	0.73	0.48–1.12	0.147	1 (0.5)	4.06	0.29–55.53	0.294
Surgical site Infection ^c	23 (3.0)	0.79	0.55–1.13	0.194	2 (0.9)	4.12	0.63–26.86	0.138
Bleeding ^d	57 (7.4)	0.41	0.32–0.53	<0.001	3 (1.4)	1.57	0.47–5.29	0.465
Prolonged Catheterization ^e	116 (15.0)	0.84	0.70–1.00	0.051	5 (2.3)	1.37	0.55–3.38	0.498

^a Including tachy- or bradycardia, arrhythmias, myocardial infarction, hypertensive crisis, hypotonia, respiratory insufficiency postoperative, pneumonia, exacerbation of chronic obstructive pulmonary disease, pulmonary edema, pleural effusion.

^b Including deep venous peripheral thrombosis and pulmonary embolism.

^c Including superficial, deep, and organ-space surgical site infections.

^d Including receipt of packed red blood cells, superficial, deep and organ-space hematomas, and blood vessel injuries.

^e Defined as postoperative catheterization >14 days.

Table 3. Clinical, histopathological and intraoperative characteristics of 994 patients undergoing ORRP or RARP

	All patients (n = 994)	ORRP (n = 775)	RARP (n = 219)
Age, years	65 (60–70)	66 (61–70)	63 (58–67)
PSA, ng/ml	7.1 (5.1–11.0)	7.3 (5.2–12.4)	6.3 (4.9–8.4)
Prostate volume, cm ³	36 (27–48)	36 (27–48)	36 (29–47)
BMI, kg/m ²			
≤29	767 (77.2)	601 (77.5)	166 (76.5)
≥30	216 (21.7)	168 (21.7)	48 (22.1)
Missing	11 (1.1)	6 (0.8)	5 (2.3)
ASA score			
≤2	755 (76.0)	575 (74.2)	180 (82.2)
≥3	212 (21.3)	181 (23.4)	31 (14.2)
Missing	27 (2.7)	19 (2.5)	8 (3.7)
Charlson score			
0–1	899 (90.4)	694 (89.5)	205 (93.6)
≥2	93 (9.4)	81 (10.5)	12 (5.5)
Missing	2 (0.2)	0 (0)	2 (0.9)
Operative time, min	195 (165–230)	180 (155–210)	240 (210–270)
LHR, beats/min	52 (47–58)	51 (47–58)	53 (49–61)
lowest MAB, mm Hg	63 (60–68)	63 (60–67)	66 (63–70)
EBL, ml	700 (400–1,000)	800 (600–1,100)	200 (100–250)
SAS	7 (6–8)	7 (6–8)	8 (7–9)
cT-stage			
1	555 (55.8)	405 (52.3)	150 (68.5)
2	323 (32.5)	258 (33.3)	65 (29.7)
3	116 (11.7)	112 (14.5)	4 (1.8)
Gleason score biopsy			
≤6	499 (50.2)	341 (44.0)	158 (72.1)
7	354 (35.6)	297 (38.3)	57 (26.0)
≥8	136 (13.7)	132 (17.0)	4 (1.8)
Missing	5 (0.5)	5 (0.6)	0
pT-stage			
pT2	701 (70.5)	519 (67.0)	182 (83.1)
pT ≥3	293 (29.5)	256 (33.0)	37 (16.9)
Gleason score specimen			
≤6	291 (29.3)	192 (24.8)	99 (45.2)
7	526 (52.9)	416 (53.7)	110 (50.2)
≥8	132 (13.3)	126 (16.3)	6 (2.7)
Prior ADT	43 (4.3)	39 (5.0)	4 (1.8)
Missing	2 (0.2)	2 (0.3)	0
pN-stage			
x	449 (45.2)	302 (39.0)	147 (67.1)
0	476 (47.9)	407 (52.5)	69 (31.5)
1	69 (6.9)	66 (8.5)	3 (1.4)
Margin status			
R0	882 (88.7)	684 (88.3)	198 (90.4)
R1	112 (11.3)	91 (11.7)	21 (9.6)

Table 3. (continued)

	All patients (n = 994)	ORRP (n = 775)	RARP (n = 219)
Stay in hospital, days	9 (8–10)	9 (9–10)	8 (7–8)
Any PAE	451 (45.4)	388 (50.1)	64 (29.2)
Low grade PAE	408 (41.0)	346 (44.6)	62 (28.3)
High grade PAE	98 (9.9)	93 (12.0)	5 (2.3)
Mortality	1 (0.1)	1 (0.1)	
Nerve preservation			
All	738 (74.2)	533 (68.8)	205 (93.6)
Unilateral	210 (21.1)	171 (22.1)	39 (17.8)
Bilateral	528 (53.1)	362 (46.7)	166 (75.8)

Values are median (IQR) or n (%).

ADT = Androgen deprivation therapy; BMI = body mass index; cT = clinical T-stage; EBL = estimated blood loss; MAB = lowest intraoperative mean arterial blood pressure; pN = pathologic N-Stage; PSA = prostate-specific antigen; pT = pathologic T-stage.

Table 4. Postoperative adverse events according to CDC and treatment of adverse events in 994 patients with ORRP and RARP

Grades	Affected system	Adverse event; specific treatment	n*	%†
I	Cardiac	Peripheral edema; furosemide	2	0.2
	Respiratory	Pleural effusion; conservative	1	0.1
	Neurological	N. obturatorius irritation ^a ; conservative	6	0.6
		Paresthesia of lower limbs and/or upper limbs; conservative	6	0.6
		Post-dural puncture headache; conservative, analgesia	2	0.2
		Vertigo; volume substitution	2	0.2
		Plexus cervicobrachialis lesion; conservative	2	0.2
		N. radialis paresis; conservative	1	0.1
		Transitory ischemic attack; conservative	1	0.1
		Nystagmus; conservative	1	0.1
	Gastrointestinal	Electrolyte disturbance ^b ; electrolyte substitution	11	1.1
		Gastroenteritis; conservative, volume substitution	2	0.2
		Postoperative nausea and vomiting; oral metoclopramide	2	0.2
		Subileus ^c ; conservative, naso-gastric tube placement	1	0.1
	Urogenital	Prolonged catheterization ^d ; cystographic control	103	10.4
		Urinary retention; transurethral catheter insertion	35	3.5
		Accidental loss of catheter; transurethral catheter insertion	5	0.5
		Hematuria; continuous bladder irrigation	2	0.2
		Urinary tract infection; conservative	1	0.1
		Asymptomatic hydronephrosis ^e ; conservative	1	0.1
		Mild progressive renal insufficiency; conservative	1	0.1
		Paraphimosis; manual reposition	1	0.1
	Musculo-skeletal	Knee joint effusion; conservative, cooling, analgesia	2	0.2
		Acute gout; analgesia	2	0.2
		Rib contusion; conservative, analgesia	1	0.1
		Exacerbation of pre-existing lumbago; physical therapy	1	0.1
		Olecranon bursitis; immobilization, analgesia	1	0.1
	Skin	Superficial burns; conservative	3	0.3
		Skin reddening bottom; conservative	1	0.1
	Ophthalmologic	Painful eyes; local anesthetic instillation	1	0.1
	Ear, nose, throat	Tinnitus; conservative	1	0.1
	Vascular	Superficial phlebitis; analgesia	1	0.1
	Surgical	Asymptomatic lymphocele ^f ; conservative	60	6.0
		Prolonged lymphorrhea ^g ; conservative	10	1.0
		Superficial wound dehiscence ^h ; conservative	6	0.6
		Superficial hematoma ⁱ ; conservative	5	0.5
		Lymphedema; conservative	2	0.2
		Supra-umbilical seroma; conservative	1	0.1

Table 4. (continued)

Grades	Affected system	Adverse event; specific treatment	n*	%†
II	Cardiac	Hypertensive crisis ^j ; medical	42	4.2
		Tachycardia syndromes ^k ; medical	7	0.7
		Hypotension ^l ; medical	4	0.4
		Angina pectoris; nitroglycerine spray	2	0.2
		Bradycardia ^m ; Atropine	1	0.1
	Respiratory	Pulmonary embolism; anticoagulation	12	1.2
		Pneumonia ⁿ ; antibiotics	9	0.9
	Neurological	Postoperative delirium; medical	4	0.4
		Anxiety disorder; medical	1	0.1
		Treatment depression; medical	1	0.1
	Gastrointestinal	Subileus ^c ; medical	3	0.3
		Pseudomembranous colitis; antibiotic	2	0.2
		Gastritis; pantoprazole, buscopan	2	0.2
	Urogenital	Urinary tract infection ^o ; antibiotic	112	11.3
		Epididymitis; antibiotic	2	0.2
	Musculo-skeletal	Acute gout; medical	3	0.3
	Skin	Allergic reaction; medical	10	1.0
		Erysipelas; antibiotic	1	0.1
	Ophthalmologic	Conjunctivitis; antibiotic	1	0.1
	Ear, nose, throat	Tonsillitis; antibiotic	1	0.1
		Oral candidosis; nystatin oral	1	0.1
		Irritating cough; codeine	1	0.1
	Vascular	Deep venous thrombosis ^p ; anticoagulation	6	0.6
	Endocrine	Hyperglycemic crisis ^q ; insuline	4	0.4
	Surgical	Bleeding anemia ^r ; transfusion of autologous packed red blood cells	53	5.3
		Prolonged lymphorrhea ^s ; antibiotic	2	0.2
		Infected lymphocele ^s ; antibiotic	1	0.1
	Other	Colonization with MRSA; decolonization therapy	2	0.2
IIIa	Neurological	Post-dural puncture headache; blood patch	1	0.1
	Gastrointestinal	Gastric ulcer bleeding; gastroscopy	1	0.1
		Esophagitis; gastroscopy, pantoprazole	1	0.1
		Paralytic ileus ^c ; gastroscopy	1	0.1
	Urogenital	Urinary retention; suprapubic catheter insertion	4	0.4
IIIb	Surgical	Symptomatic lymphocele ^t ; pigtail catheter drainage	10	1.0
		Superficial wound dehiscence ^h ; suture	4	0.4
	Cardiac	Acute coronary syndrome; coronary artery bypass graft	1	0.1
	Gastrointestinal	Paralytic ileus ^c ; central venous and peridural catheter, medical	1	0.1
	Urogenital	Symptomatic hydronephrosis ^u ; nephrostomy	3	0.2
		Urinary retention; cystoscopy, transurethral catheter insertion	2	0.2
		Spermatic cord hemorrhage; revision, orchiectomy	1	0.1
	Vascular	Acute arterial occlusion lower extremity; thromboendarterectomy, fasciotomy	1	0.1
	Surgical	Symptomatic lymphocele ^t ; open or laparoscopic fenestration	41	4.1
		Deep wound dehiscence ^v ; revision, vacuum therapy, wound closure	16	1.6
		Organ space hematoma ^w ; revision	4	0.4
		Inguinal hernia; open hernia repair	1	0.1
		Internal iliac arterial laceration; surgical revision	1	0.1

Table 4. (continued)

Grades	Affected system	Adverse event; specific treatment	n*	%†
IVa	Cardiac	Myocardial infarction ^x ; ICU, PTCA/stent	4	0.4
		Cardiac dysrhythmia ^y ; ICU, with or without reanimation, medical	4	0.4
		In-stent thrombosis ^x ; ICU, PTCA/Stent	2	0.2
		Cardiac dysrhythmia ^y ; ICU, pacemaker implantation	1	0.1
		Hypertensive crisis ^l ; ICU, medical	1	0.1
	Respiratory	Postoperative respiratory insufficiency; ICU, medical	1	0.1
	Gastrointestinal	Paralytic ileus ^c ; ICU, explorative laparotomy	1	0.1
IVb	Cardiac	Multiple organ dysfunction syndrome; ICU, invasive ventilation, medical, hemodialysis	2	0.2
V	Respiratory	Pulmonary embolism; fatal	1	0.1

* A patient may have more than 1 adverse event; † Of all complications; ICU, intensive care unit. Definitions of complications: ^a hypoesthesia and/or hyperesthesia and/or temporary loss of strength within innervation area of obturator nerve.

^b Hypokalemia or hyponatremia.

^c No productive bowel activity for >3 days postoperative.

^d Catheterization >14 days.

^e Ultrasound evidence of hydronephrosis without pain and without increase of baseline creatinine.

^f Ultrasound detection of pelvic anechoic mass of <50 cm³ without concomitant pain, signs of infection, swelling of extremities and dysesthesia in patients with lymphadenectomy.

^g Secretion of drain >100 cm³ for 3 or more days postoperative without evidence of infection.

^h No clinical evidence of fascia dehiscence.

ⁱ Ultrasound detection of hypo-/anechoic mass between skin and fascia.

^j Systolic blood pressure >180 mm Hg in patients with adequate pain management.

^k Persistent heart rate >100 min with or without arrhythmia in patients with adequate pain management and hemoglobin >10 mg/dl.

^l Persistent systolic blood pressure <90 mm Hg with adequate volume substitution and hemoglobin >10 mg/dl.

^m Persistent heart rate <60 min with adequate volume substitution.

ⁿ Radiographic evidence of pulmonary infiltrates.

^o Postoperative positive dipstick test and subsequent positive urine culture.

^p Duplex ultrasound or imaging testing with evidence of deep venous thrombosis.

^q Blood sugar level >200 mg/dl.

^r Intra- or postoperative symptomatic anemia (hypotension, tachycardia and/or dyspnea), absolute indication hemoglobin <8 mg/dl, in patients with cardiac comorbidity with hemoglobin <10 mg/dl.

^s Ultrasound detection of pelvic anechoic mass of <50 cm³ in patients with lymphadenectomy with clinical signs of infection and no other focus.

^t Ultrasound detection of pelvic anechoic mass of >50 or <50 cm³ and concomitant pain, signs of infection, swelling of extremities and dysesthesia in patients with lymphadenectomy.

^u Ultrasound evidence of hydronephrosis with pain and/or increase of baseline creatinine.

^v Superficial wound and fascial dehiscence.

^w Ultrasound or image evidence of pelvic hematoma.

^x With or without ST elevation on electrocardiogram and positive troponin testing.

^y Tachy- or bradycard arrhythmia syndromes.

injury (n = 1), and reanimation (n = 1), which were treated immediately. Postoperatively, 49.9% (387/775) of the patients experienced at least one PAE and 18.6% (144/775) of the patients had 2 or more PAE. PAE were classified as CDC grades I, II, III and IV in 43.8% (267/609), 38.9% (237/609), 14.4% (88/609) and 2.6% (16/609) respectively. The 30-day mortality rate (grade V) was 0.1% (1/775). All postoperative PAE and their management are shown in table 4.

The median SAS and its composing variables are shown in table 3. No patient had a SAS ≤2 and 2.0%

(19/775) had a SAS ≤4. The mean SAS was significantly higher in patients with no adverse events (6.93 ± 1.04) and lower in patients with any and CDC1–2 PAE (6.62 ± 1.17 and 6.62 ± 1.18; p < 0.001, respectively. Figure 1a shows the distribution of percentages of any, CDC1–2 and CDC3–5 PAE over given SAS values.

In the univariable analyses, lower SAS scores were associated with any and CDC1–2 PAE with p < 0.001 respectively (data not shown). In the ORRP cohort, a lower SAS was associated with bleeding complications (p < 0.001; table 2). In the sensitivity analyses for the ORRP

Fig. 1. a Proportion of 30-day overall, CDC1-2, and CDC3-5 PAE among 775 patients with ORRP in relation to the SAS. A single patient may have more than one complication. Table gives the number of PAE for single SAS values. **b** Proportion of 30-day over-

all, CDC1-2, and CDC3-5 PAE among 219 patients with RARP patients in relation to the SAS. A single patient may have more than one complication. Table gives the number of PAE for single SAS values.

cohort, the SAS was not associated with any, CDC1-2, and CDC3-5 PAE (data not shown).

Multivariable analysis was performed controlling for variables that were found to be significant on univariable analysis; results are shown in table 5. In the ORRP cohort, the SAS was associated with any and CDC1-2 PAE (OR 0.76, 95% CI 0.66–0.88; $p < 0.001$ and OR 0.79, 95% CI 0.69–0.91; $p = 0.001$, respectively).

Results of the RARP Population

A total of 83 PAE was observed in 219 patients. Of those, 98.8% (82/83) occurred postoperatively. One intra-operative Satava grade I PAE occurred (technical failure, conversion to open surgery). Postoperatively, 29.2% (64/219) of the patients experienced at least one PAE and 6.8% (15/219) of the patients had 2 or more PAE. We observed a total of 82 postoperative PAE, which were classified as CDC grades I, II, III and IV in 29.3% (24/82), 63.4% (52/82), 6.1% (5/82) and 1.2% (1/82), respectively.

The median SAS and its composing variables are shown in table 3. No patient had a SAS ≤ 2 and 0.5% (1/219) had a SAS ≤ 4 . The mean SAS was not significantly different in patients with no, any, CDC1-2, and CDC3-5 PAE (7.81 ± 1.09 , 8.05 ± 1.05 , 8.02 ± 1.03 , and 8.80 ± 0.84 ; $p > 0.05$, respectively). Figure 1b shows the distribu-

tion of percentages of any, CDC1-2 and CDC3-5 PAE over the given SAS values.

In the RARP cohort, lower SAS scores were not associated with any, CDC1-2 and CDC3-5 PAE with $p > 0.05$ (data not shown). Also, the SAS was not associated with specific complications ($p > 0.05$, respectively; table 2). In the sensitivity analyses of the RARP cohort, the SAS was not associated with any, CDC1-2, and CDC3-5 PAE (data not shown).

Discussion

By applying the SAS score and using a standardized assessment of intra- and postoperative adverse events in a contemporary series of patients undergoing radical prostatectomy for localized PCA, we found lower SAS scores in patients with any PAE. The SAS was an independent predictor of any and CDC1-2 PAE, whereas CDC3-5 PAE did not have any predictors. However, this was true only for ORRP patients; PAE in RARP patients were not associated with the SAS. To the best of our knowledge, no other report exists, which applies the SAS in a radical prostatectomy setting. Our results are supported by Prasad et al. [8] who found a progressive de-

Table 5. Multivariable binominal logistic regression analysis with no PAE vs. any, CDC1–2 or CDC3–5 in ORRP and RARP patients

	No PAE vs. any			No PAE vs. Clavien 1–2			No PAE vs. Clavien 3–5		
	p value	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI
<i>ORRP (n = 775)</i>									
SAS (cont.)	<0.001	0.76	0.66–0.88	0.001	0.79	0.69–0.91		Not applied	
Age (cont.), years	<0.001	1.05	1.02–1.07	0.002	1.04	1.01–1.06	0.1	1.03	0.99–1.07
BMI (≤ 29 vs. ≥ 30)*	0.049	1.46	1.00–2.12	0.02	1.54	1.07–2.20		Not applied	
ASA (≤ 2 vs. ≥ 3)*	0.3	1.21	0.84–1.76		Not applied		0.007	1.91	1.19–3.05
Charlson score (≤ 1 vs. ≥ 2)*	0.2	1.39	0.83–2.35	0.1	1.60	0.99–2.61		Not applied	
Pelvic lymphadenectomy (none vs. yes)*	0.002	1.73	1.22–2.46	0.2	1.24	0.87–1.75	<0.001	2.94	1.66–5.20
Nerve-sparing (none vs. any)*	0.1	0.72	0.49–1.06	0.023	0.64	0.44–0.94		Not applied	
Limited vs. advanced disease (pT3b or N+)*	0.3	1.28	0.83–1.97	0.2	1.31	0.86–1.99	0.6	1.17	0.69–1.97
<i>RARP (n = 219)</i>									
SAS (cont.)		Not applied			Not applied			Not applied	
Age (cont.), years		Not applied			Not applied			Not applied	
BMI (≤ 29 vs. ≥ 30)*		Not applied			Not applied			Not applied	
ASA (≤ 2 vs. ≥ 3)*		Not applied			Not applied			Not applied	
Charlson score (≤ 1 vs. ≥ 2)*		Not applied			Not applied			Not applied	
Pelvic lymphadenectomy (none vs. yes)*		Not applied			Not applied			Not applied	
Nerve-sparing (none vs. any)*		Not applied			Not applied			Not applied	
Limited vs. advanced disease (pT3b or N+)*		Not applied			Not applied			Not applied	

* Reference. BMI = Body mass index.

crease in complications in patients with increasing SAS in a series of 155 consecutive patients who underwent radical cystectomy. In this series, the SAS was also associated with major complications, as defined by the National Surgery Quality Improvement Program [12], which occurred in 26% of the study population. However, due to the complexity of radical cystectomy, these patients are prone to major or CDC3–5 complications [13]. Prasad et al. [8] did not perform multivariable analyses due to a limited number of cases in that series. In a recently published series of 886 patients with renal mass excision, Ito et al. [7] found that patients with an SAS ≤ 4 were 3.7 times (95% CI 1.42–9.54, $p = 0.01$) more likely to experience a major complication when compared to patients with an SAS ≥ 8 . In our series, a lower SAS was not independently associated with CDC3–5 PAE. Patients who are scheduled for radical prostatectomy are generally in a better health condition compared to patients who undergo radical cystectomy or renal mass excision. Our finding might be supported by an analysis [14] of 123,864 surgical procedures that showed that patients who underwent a urologic procedure had a weaker association of SAS and the probability to die within 7 days after surgery. The mortality rate of the latter study and our study

(0.5 and 0.1% at 30 days, respectively) are comparable. However, no information on the performed type of urologic procedures was available in this report. Other non-urologic surgical disciplines that applied the SAS also found that patients with lower scores had a higher incidence of complications. Urrutia et al. [15] applied the SAS to a group of 280 patients undergoing spine surgery. They found a major complication rate as defined by Gawande et al. [5] of 17.4% (4/23) in patients with an SAS ≤ 4 , which resembled a 10.61 increased relative risk (95% CI 1.25–90) of suffering a complication compared to patients with an SAS of 9–10. In the validation study of the SAS in 4,119 patients with general or vascular surgery, Regenbogen et al. [6] found major complications in 56.3% (72/128) of the patients with an SAS ≤ 4 compared to 5.0% (72/1,441) with a score ≥ 9 (relative risk 11.3, 95% CI 8.6–14.8; $p < 0.001$). A comparison of the aforementioned reports to our series is difficult due to the different surgical procedures and patient collectives. Additionally, these were focused only on major complications or death and did not address the incidence of any PAE and their correlation with the SAS. Also, there was no standardized reporting system for complications applied. Almost all of the mentioned studies used an SAS ≤ 4 as cut-off value to

define patients at utmost risk for major adverse events and or death. Because there were only 20 patients with an SAS ≤ 4 in our patient collective, we decided against a categorization and applied a continuous SAS in our statistical models.

In our series, 2 different surgical approaches are analyzed. Based on baseline population differences and multiple surgeons at different learning stages, a direct comparison of these 2 approaches is not possible. The finding of differences in complication rates between the 2 procedures is backed by literature [2, 16, 17]. Underlying reasons might be a higher incidence of asymptomatic lymphoceles and prolonged catheterization rates, which occurred more frequently with ORRP. Additionally, surgical site infections requiring a revision occurred almost solely with ORRP. Interestingly, a worse American Society of Anesthesiologists (ASA) did predict high-grade PAE, whereas increasing age did not. However, increasing age was associated with any and low-grade PAE. The underlying reasons for this observation are not completely clear. Increasing age is associated with a higher ASA score in our population (data not shown). However, as age was included as a continuous variable in the models, the relatively low frequency of high-grade PAE compared to any/low-grade PAE might result in a non-significant result. Baseline patient characteristics indicate a clear selection bias for patients undergoing RARP with more favorable clinical and histopathological parameters (table 3). RARP patients were younger than ORRP patients and this may have led to a lower complication rate. Further, younger patients might have more capacity to deal with the stress of surgery [18]. Vice versa, the SAS might be influenced even by the surgical approach. In patients with pneumoperitoneum and steep Trendelenburg position, the MAP may be increased by up to 25% [19]. In our study, patients with RARP had an intraoperatively increased MAP (66 mm Hg). However, we are unable to assess the extent to which the latter finding restricts the applicability of the SAS to RARP patients.

Our study is not devoid of limitations. A first important aspect is the substantial influence of the anesthesiologists' management with respect to blood pressure and heart rate control. On the one hand, general and epidural/local anesthetic drug effects are accompanied with circulatory depression as insufficient depth of anesthesia may result in stress response-related hypertension. Because the induction period of anesthesia is frequently associated with these hemodynamic response changes affecting the SAS, we only assessed MAP and LHR values during the time period starting from incision until the time of

wound closure. Second, there is increasing evidence, that intraoperative fluid management may have an impact on adverse events and mortality rates after surgery [20]. As our patients were not receiving a restrictive or goal-directed fluid management that might be beneficial and associated with fewer PAE, this might introduce an additional bias to our results. However, in the original SAS study [5] and also in the validation study [6], intraoperative fluid volume has not been addressed. A third important aspect is the patient's preoperative hemodynamic status. In vascular or trauma surgery, intraoperative tachycardia and hypotension are encountered more frequently and are associated with a poorer outcome. This may explain the better fit of the SAS as a predictor for mortality and high-grade PAE in these patient collectives [6, 14]. Our patients were screened preoperatively through electrocardiogram, exercise electrocardiogram and the pulmonary function test to identify obvious cardio-pulmonary morbidity, which is considered a contraindication for radical prostatectomy, and the exclusion of patients with serious cardiac comorbidity might result in presumably more stable hemodynamic conditions indicated by higher SAS scores intraoperatively. A significant proportion of adverse events of radical prostatectomy occurs well after 30 days [16]. As our follow-up was limited to 30 days, especially CDC3–5 PAE requiring surgical interventions, such as bladder neck stricture or urethral stricture, are not included because these often occur well after 30 days. However, the SAS was designed primarily to predict early adverse events. Additionally, we are unable to assess the impact of the length of hospital stay on the occurrence of complications. A prolonged stay has been associated with an increased occurrence of PAE. Vice versa PAE may prolong the hospital stay as well. We are unable to determine to which extent this limitation influences our results. Finally, readmissions to other hospitals or other physician consultations were not assessed, resulting in a possible underreporting of adverse events. The strength of our study lies in the thorough and very detailed standardized assessment of complications in a large contemporary series of open retropubic and RARP.

Conclusion

Lower SAS values identify patients at risk for any PAE after open radical prostatectomy. It might serve as an objective variable of the intraoperative course and create individualized handover processes to assess the

need for an intensified postoperative care. However, the SAS is reflecting the challenge of mutual surgical and anesthesiology procedure management in the perioperative setting. A specific cut-off value for prostatectomy patients has to be determined and the influence of other parameters such as the surgical approach and intraoperative fluid management on postoperative adverse events warrants further evaluation, ideally in a multicentric setting.

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Disclosure Statement

All authors have no conflicts of interest.

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