Low-dose acetylsalicylic acid and bleeding risks with ventriculoperitoneal shunt placement

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OBJECTIVE Ventriculoperitoneal (VP) shunt placement is a common procedure for the treatment of hydrocephalus following diverse neurosurgical conditions. Most of the patients present with other comorbidities and receive antiplatelet therapy, usually acetylsalicylic acid (ASA). Despite its clinical relevance, the perioperative management of these patients has not been sufficiently investigated. The aim of this study was to compare the peri- and postoperative bleeding complication rates associated with ASA intake in patients undergoing VP shunt placement.

METHODS Of 172 consecutive patients undergoing VP shunt placement between June 2009 and December 2015, 40 (23.3%) patients were receiving low-dose ASA treatment. The primary outcome measure was bleeding events in ASA users versus nonusers, whereas secondary outcome measures were postoperative cardiovascular events, hematological findings, morbidity, and mortality. A subgroup analysis was conducted in patients who discontinued ASA treatment for < 7 days (n = 4, ASA Group 1) and for ≥ 7 days (n = 36, ASA Group 2).

RESULTS No statistically significant difference for bleeding events was observed between ASA users and nonusers (p = 0.30). Cardiovascular complications, surgical morbidity, and mortality did not differ significantly between the groups either. Moreover, there was no association between ASA discontinuation regimens (< 7 days and ≥ 7 days) and hemorrhagic events.

CONCLUSIONS Given the lack of guidelines regarding perioperative management of neurosurgical patients with antiplatelet therapy, these findings elucidate one issue, showing comparable bleeding rates in ASA users and nonusers undergoing VP shunt placement.

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KEY WORDS ventriculoperitoneal shunt; acetylsalicylic acid; bleeding events; antithrombotic therapy

VENTRICULOPERITONEAL (VP) shunt placement is a common neurosurgical procedure for the treatment of hydrocephalus following diverse conditions like normal-pressure hydrocephalus (NPH), intracranial hemorrhage, aneurysmal subarachnoid hemorrhage (aSAH), meningitis, or trauma.^{4,8,12–14} Generally, NPH occurs in the 6th and 7th decade of life,^{3,15} which explains why many of these patients receive low-dose acetylsalicylic acid (ASA) treatment for secondary prophylaxis.² On the other hand, patients presenting with aSAH and who are treated by stent-assisted coil insertion or flow diversion are often treated with antiplatelet medication to avoid in-stent thrombosis. Even though many patients needing a VP shunt are treated with low-dose ASA, data on its impact on VP shunt surgery are sparse. A recent study demonstrated that patients on an ASA regimen in whom shunts were

implanted had an increased risk of postoperative chronic subdural hematoma (cSDH).² Another study investigating the effects of dual antiplatelet therapy in patients with aSAH showed an increased but low rate of hemorrhagic complications associated with shunting.¹³ With the current study we aimed to elucidate the effect of ASA treatment on bleeding events in patients undergoing VP shunt placement.

Methods

Of 172 consecutive patients undergoing VP shunt placement between June 2009 and December 2015 at our institution, 40 (23.3%) patients were receiving low-dose ASA treatment (100 mg orally administered once a day; ASA group), whereas 132 (76.7%) were nonusers (control

ABBREVIATIONS ASA = acetylsalicylic acid; aSAH = aneurysmal subarachnoid hemorrhage; CAD = coronary artery disease; cSDH = chronic subdural hematoma; Hb = hemoglobin; LMWH = low-molecular-weight heparin; NPH = normal-pressure hydrocephalus; PBC = packed blood cells; Tc = thrombocyte; VP = ventriculoperitoneal.

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group). The diagnosis in these patients was symptomatic hydrocephalus caused by various underlying diseases (Table 1), confirmed by CT or MRI. All patients received low-molecular-weight heparin (LMWH) in a prophylactic weight-adapted dosage (< 80 kg, 2500 U of LMWH; ≥ 80 kg, 5000 U of LMWH) 24 hours postoperatively. None of the cases were excluded from the study.

In the ASA group, antithrombotic medication was discontinued 8.9 ± 5.9 days prior to surgery and resumed 60.68 ± 127.5 days postoperatively. The ASA users were significantly older compared with nonusers (mean age 69.5 ± 12.6 years and 61.3 ± 17.1 years, respectively [$p = 0.01$]). Also, significantly more patients in the ASA group were men, and significantly more suffered from arterial hypertension, coronary artery disease (CAD), and atrial fibrillation. Moreover, in the ASA group there was a significantly higher percentage of patients with a coronary stent, coronary bypass surgery, and a history of transient ischemic attack and/or stroke. Distribution of sex, age, comorbidities, underlying disease, side of shunting, American Society of Anesthesiologists score, and concomitant antiplatelet or anticoagulation therapy in each group are shown in Table 1.

Data on operating time, intraoperative blood loss, pre- and postoperative hemoglobin (Hb) and thrombocyte (Tc) counts, transfusion of packed blood cells (PBC), and clinical outcome were additionally collected. Intraoperative blood loss was recorded in the anesthetic report and was assessed by subtracting the amount of blood collected in the suction tube at the end of surgery from the amount of fluids applied into the surgical field. Preoperative laboratory values were collected 1 day prior to or on the same day of the surgery, whereas postoperative laboratory values were collected on the 1st or 2nd postoperative day. Postoperative complications such as bleeding, cardiovascular events, morbidity, and mortality were also compared. The mean clinical and radiological follow-up time in the ASA group was 39.56 ± 71.9 days (range 3–351 days) and 3.54 ± 3.2 days (range 0–19 days), respectively. In the control group, the clinical follow-up was 64.08 ± 117.7 days (range 2–433 days) and radiological follow-up was 3.29 ± 2.1 days (range 0–13 days) after surgery.

The primary outcome measure was an intra- or extracranial bleeding event (treated by surgery or conservatively). Secondary outcome measures were postoperative thromboembolic events (defined as myocardial infarction [STEMI/NSTEMI: ST-elevation myocardial infarction/non-ST elevation myocardial infarction], cerebrovascular insult, peripheral arterial occlusion, deep vein thrombosis, or pulmonary embolism); systemic and infectious complications (defined as surgical or systemic infection, other medical complications); amount of intraoperative blood loss; amount of transfused PBC; hematological findings; operating and hospitalization times; overall morbidity and mortality; and clinical outcome.

An additional subgroup analysis of only ASA users was conducted, comparing bleeding and thromboembolic events and hematological findings in patients discontinuing ASA treatment for < 7 days (ASA Group 1: 4 cases [10%], 3 females [75%]) and for ≥ 7 days (ASA Group 2: 36 cases [90%], 9 females [25%]). Antithrombotic medica-

TABLE 1. Baseline characteristics in 172 patients with VP shunt placement

Characteristic	Total (%), n = 172	ASA Group (%), n = 40	Control Group (%), n = 132	p Value*
Female sex	76 (44.2)	12 (30.0)	64 (48.5)	0.049
Age in yrs, mean ± SD	63.2 ± 16.5	69.5 ± 12.6	61.3 ± 17.1	0.01
Concomitant blood thinners				
Clopidogrel therapy	7 (4.1)	2 (5.0)	5 (3.8)	0.67
Warfarin therapy	12 (7.0)	3 (7.5)	9 (6.8)	0.1
NOAC therapy	2 (1.2)	0	2 (1.5)	1.0
Secondary diagnosis				
CAD	27 (15.7)	14 (35.0)	13 (9.8)	<0.01
Coronary stent	5 (2.9)	4 (10.0)	1 (0.8)	0.01
Arterial hypertension	81 (47.1)	31 (77.5)	50 (37.9)	<0.01
Coronary bypass	2 (1.2)	2 (5.0)	0 (0)	0.049
Carotid stenosis	1 (0.6)	1 (2.5)	0 (0)	0.23
TIA/CVI	27 (15.7)	12 (30.0)	15 (11.4)	0.01
PAOD	14 (8.1)	6 (15.0)	8 (6.1)	0.10
Atrial fibrillation	3 (1.7)	3 (7.5)	0 (0)	0.01
Hypercholesterolemia	15 (8.7)	7 (17.5)	22 (16.7)	0.28
American Society of Anesthesiologists score				0.10
I	4 (2.3)	1 (2.5)	3 (2.3)	
II	28 (16.3)	4 (10.0)	24 (18.2)	
III	125 (72.7)	28 (70.0)	97 (73.5)	
IV	12 (7.0)	6 (15.0)	6 (4.5)	
VP shunt location				
Lt	34 (19.8)	3 (7.5)	31 (23.5)	0.03
Rt	138 (80.2)	37 (92.5)	101 (76.5)	
Indication for VP shunt				0.39
NPH	65 (37.8)	19 (47.5)	46 (34.8)	
TBI	22 (12.8)	2 (5.1)	20 (15.2)	
aSAH	39 (22.7)	13 (32.5)	26 (20.0)	
Tumor obstruction	10 (5.8)	1 (2.6)	9 (6.8)	
Meningitis	7 (4.1)	0 (0)	7 (5.3)	
Postop hydrocephalus	9 (5.2)	1 (2.6)	8 (6.1)	
IVH	12 (7.0)	3 (7.7)	9 (6.8)	
Pseudotumor cerebri	2 (1.2)	0 (0)	2 (1.5)	
Stroke	3 (1.7)	1 (2.6)	2 (1.5)	
Idiopathic NPH	1 (0.6)	0 (0)	1 (0.8)	

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TABLE 1. Baseline characteristics in 172 patients with VP shunt placement

Characteristic	Total (%), n = 172	ASA Group (%), n = 40	Control Group (%), n = 132	p Value*
Indication for VP shunt (<i>continued</i>)				0.39
Aqueductal stenosis	1 (0.6)	0 (0)	1 (0.8)	
Syringomyelia	1 (0.6)	0 (0)	1 (0.8)	

CVI = cerebrovascular insult; IVH = intraventricular hemorrhage; NOAC = non-vitamin K antagonist oral anticoagulants; PAOD = peripheral artery occlusive disease; TBI = traumatic brain injury; TIA = transient ischemic attack.

* Boldface type indicates statistical significance ($p < 0.05$).

tion was stopped 1 ± 1.4 days and 9.8 ± 5.5 days prior to surgery in ASA Group 1 and ASA Group 2, respectively ($p = 0.001$). The ASA treatment was resumed postoperatively after 3.3 ± 1.3 days in the ASA Group 1 and after 67.1 ± 133.0 days in the ASA Group 2 ($p = 0.01$).

The study protocol was approved by the local ethics committee (EKNZ, Basel, Switzerland). All statistical analyses were done using SPSS Statistics software, version 21.0 (IBM Corp., 2012). Contingency tests were done using Fisher's exact test, whereas all other calculations were done using the Mann-Whitney U-test. A p value of < 0.05 was considered significant. Values for continuous variables are expressed as the mean $\pm$ SD throughout.

Results

Hemorrhagic and Thromboembolic Events

The overall bleeding events rate was 7% ($n = 12$). One patient (2.5%) and 11 patients (8.3%) had a bleeding event in the ASA and control groups, respectively, showing no

significant difference ($p = 0.30$). The overall rate of thromboembolic complications was 2.5% ($n = 1$) in the ASA group, whereas no events occurred in the control group ($p = 0.23$). The only patient with a bleeding event in the ASA group suffered from asystole and eventually died after resuscitation (Table 2).

Morbidity and Mortality

Overall morbidity did not differ significantly between the 2 groups, with 20% ($n = 8$) in the ASA group and 26.5% ($n = 35$) in the control group ($p = 0.53$). The mortality rate was 2.5% ($n = 1$) in the ASA group and 1.5% ($n = 2$) in the control group, showing no significant difference ($p = 0.55$) (Table 2).

Operating and Hospitalization Times

The mean operating time in the ASA and control groups was 86.84 ± 11.6 minutes and 88.54 ± 18.9 minutes, respectively ($p = 0.84$). The mean hospitalization time in the ASA group was 14.95 ± 10.1 days, and in the control group it was 14.99 ± 11.0 days, showing no significant difference ($p = 0.72$) (Table 2).

Intraoperative and Postoperative Blood Loss, Blood Transfusion, and Hematological Findings

The average intraoperative blood loss was 39.25 ± 60.8 ml in the ASA group and 41.97 ± 63.3 ml in the control group, showing no significant difference ($p = 0.77$). In the ASA group 0.03 ± 0.158 U of PBC were transfused intraoperatively, whereas in the control group intra- or postoperative transfusions of PBC were not necessary ($p = 0.07$). Preoperative and postoperative hematological findings did not differ significantly between the groups. Intraoperative or postoperative transfusion of Tc was not necessary in either group (Table 3). The mean preoperative international normalized ratio was < 1.2 in all patients.

TABLE 2. Primary and secondary outcome measurements in 172 patients with VP shunt placement

Outcome Measure	Total (%), n = 172	ASA Group (%), n = 40	Control Group (%), n = 132	p Value
Overall bleeding events	12 (7)	1 (2.5)	11 (8.3)	0.30
Thromboembolic complications	1 (0.6)	1 (2.5)	0 (0)	0.23
Morbidity				
Systemic & infectious complications	16 (9.3)	3 (7.5)	13 (9.8)	0.77
Surgical site infections	10 (5.8)	2 (5.0)	8 (6.1)	1.0
Morbidity w/o bleeding events	41 (23.8)	17 (42.5)	24 (18.2)	1.0
Overall morbidity	43 (25.0)	8 (20.0)	35 (26.5)	0.53
Mortality	3 (1.7)	1 (2.5)	2 (1.5)	0.55
Op time in min, mean $\pm$ SD	88.15 ± 17.5	86.84 ± 11.6	88.54 ± 18.9	0.84
Hospitalization time in days, mean $\pm$ SD	14.98 ± 10.7	14.95 ± 10.1	14.99 ± 11.0	0.72
Postop clinical condition				0.20
Better	106 (61.6)	24 (60.0)	82 (62.1)	
Same	27 (15.7)	6 (15.0)	21 (16.0)	
Worse	3 (1.7)	2 (5.0)	1 (0.8)	
Follow-up in days, mean $\pm$ SD				
Clinical follow-up	58.31 ± 108.9	39.56 ± 71.9	64.08 ± 117.7	0.80
Radiological follow-up	3.35 ± 2.4	3.54 ± 3.2	3.29 ± 2.1	0.91

TABLE 3. Hematological findings in 172 patients with VP shunt placement

Finding	Total, n = 172	ASA Group, n = 40	Control Group, n = 132	p Value
Hb level preop in g/L, mean $\pm$ SD	328.38 $\pm$ 138.7	129.6 $\pm$ 22.6	130.3 $\pm$ 22.6	0.91
Tc level preop in g/L $\times 10^9$, mean $\pm$ SD	255.9 $\pm$ 104.5	347.6 $\pm$ 171.6	322.9 $\pm$ 127.9	0.97
Hb level postop in g/L, mean $\pm$ SD	120.1 $\pm$ 20.6	120.5 $\pm$ 19.6	118.5 $\pm$ 24.3	0.62
Tc level postop in g/L $\times 10^9$, mean $\pm$ SD	333.46 $\pm$ 121.9	343.8 $\pm$ 157.8	330.6 $\pm$ 110.8	0.74
Blood loss in ml, mean $\pm$ SD	41.34 $\pm$ 62.6	39.25 $\pm$ 60.8	41.97 $\pm$ 63.3	0.77
Intraop PBC units, mean $\pm$ SD*	0.03 $\pm$ 0.158	0.03 $\pm$ 0.158	0	0.07

* Used in only 1 case.

Clinical Outcome

In the ASA group 15.0% of the patients (n = 6) had an unchanged clinical condition, 5.0% (n = 2) had a worsening one, and 60.0% (n = 24) showed an improvement of their clinical condition. In the control group 16.0% (n = 21) of the patients had an unchanged clinical condition, whereas 0.8% (n = 1) showed worsening, and 62.1% (n = 82) showed improvement of their clinical condition. The clinical outcome did not differ significantly between the groups (p = 0.20) (Table 2).

Subgroup Analysis

Our additional subgroup analysis—of ASA users only—showed no significant difference in the baseline characteristics described above (results not shown). The overall rate of bleeding events was 2.5% (n = 1) and showed no significant difference between the 2 groups (p = 1). The only bleeding event, a discrete bleed along the course of the ventricular catheter accompanied by a small acute SDH,

which was managed conservatively without influencing the patient's outcome, occurred on the 3rd postoperative day. The ASA treatment was resumed in this patient on the 2nd postoperative day. Thromboembolic events in both groups (0% in ASA Group 1 vs 2.8% (n = 1) in ASA Group 2; p = 1.0) showed no significant difference. Patients in ASA Group 1 required significantly more units of PBC intraoperatively and showed significantly lower Hb values postoperatively than patients in ASA Group 2 (p = 0.003 and p = 0.049 for PBC and Hb levels, respectively). Morbidity, mortality, other perioperative complications, and clinical outcomes were not significantly influenced by the ASA regimen administered (Table 4).

Discussion

In this study, in which the aim was to investigate the rates of bleeding events in ASA users and nonusers undergoing VP shunt placement, our main results showed no statistically significant difference between these groups

TABLE 4. Subgroup analysis of ASA users only*

Factor	Total (%), n = 40	ASA Group 1 (%), n = 4	ASA Group 2 (%), n = 36	p Value†
Bleeding events	1 (2.5)	0 (0)	1 (2.8)	1
Thromboembolic complications	1 (2.5)	0 (0)	1 (2.8)	1
Morbidity w/o bleeding events	7 (17.5)	1 (25.0)	6 (16.7)	0.55
Mortality	1 (2.5)	0 (0)	1 (2.8)	1
Hb level preop in g/L, mean $\pm$ SD	130.3 $\pm$ 22.6	110.0 $\pm$ 13.7	132.7 $\pm$ 22.4	0.06
Tc level preop in g/L $\times 10^9$, mean $\pm$ SD	347.6 $\pm$ 171.6	491.8 $\pm$ 231.6	330.7 $\pm$ 159.1	0.07
Hb level postop in g/L, mean $\pm$ SD	118.5 $\pm$ 24.3	96.0 $\pm$ 7.1	122.2 $\pm$ 24.2	0.049
Tc level postop in g/L $\times 10^9$, mean $\pm$ SD	343.8 $\pm$ 157.8	368.8 $\pm$ 159.2	336.6 $\pm$ 159.9	0.51
Average blood loss in ml, mean $\pm$ SD	39.3 $\pm$ 60.8	87.5 $\pm$ 143.6	33.9 $\pm$ 45.4	0.78
Intraop PBC units, mean $\pm$ SD‡	0.03 $\pm$ 0.16	0.025 $\pm$ 0.05	0	0.003
Op time in min, mean $\pm$ SD	86.8 $\pm$ 11.6	80.0 $\pm$ 17.3	87.4 $\pm$ 11.2	0.29
Hospitalization time in days, mean $\pm$ SD	15.0 $\pm$ 10.1	19.5 $\pm$ 10.8	14.4 $\pm$ 10.0	0.43
Postop clinical condition				0.59
Better	24 (60.0)	4 (100)	20 (55.6)	
Same	6 (15.0)	0 (0)	6 (16.7)	
Worse	2 (5.0)	0 (0)	2 (5.6)	
ASA discontinuation preop in days, mean $\pm$ SD	8.9 $\pm$ 5.9	1.0 $\pm$ 1.4	9.8 $\pm$ 5.5	0.001
ASA start postop in days, mean $\pm$ SD	60.7 $\pm$ 127.5	3.3 $\pm$ 1.3	67.1 $\pm$ 133.0	0.01

* ASA Group 1 consisted of patients who discontinued ASA for < 7 days; ASA Group 2 consisted of patients who discontinued ASA for $\geq$ 7 days.

† Boldface type indicates statistical significance (p < 0.05).

‡ Used in only 1 case.

(2.5% vs 8.3%, $p = 0.30$). In addition, rates of thromboembolic events, surgical morbidity, mortality, perioperative complications, hematological findings, and clinical outcome did not differ significantly. A subgroup analysis of ASA users alone showed no statistically significant difference for bleeding events in patients discontinuing ASA for < 7 days and ≥ 7 days (0% vs 2.8%, respectively; $p = 1$). Moreover, no significant difference was found for thromboembolic events, morbidity, mortality, and clinical outcome between the groups. However, a significantly higher number of PBC units was administered intraoperatively, and lower postoperative Hb values were seen in patients in whom ASA was discontinued < 7 days. This occurred even though the intraoperative amount of blood loss did not differ significantly between the groups.

Association Between ASA Therapy and Bleeding Events After VP Shunt Placement

There are only a very few retrospective studies on the effects of antithrombotic therapy in neurosurgical patients. A recent study in patients with cSDH showed no significant association between early postoperative ASA resumption and increased recurrence rates.¹⁰ McDonald's group (see Guha et al.) also investigated the effect of ASA on the recurrence rate in cSDH and recommended early postoperative resumption of ASA treatment, namely after 3 days.⁷ Mahaney et al. show an increased but low rate of symptomatic intracranial hemorrhage associated with dual antiplatelet therapy, and suggest that VP shunt implantation without discontinuation of dual antiplatelet therapy might be feasible.¹³ A study of patients with NPH who received ASA therapy and were treated with a VP shunt showed a significant increase of the occurrence of cSDH associated with antithrombotic therapy compared with nonusers.² Those authors proposed withholding ASA treatment 7 days prior to surgery and resuming it on the 1st–2nd postoperative day. However, it was shown that the antithrombotic effect of ASA vanishes in half of the patients after 72 hours and in 80% of the cases after 96 hours.⁹ This brings into question the common practice of most surgeons to discontinue ASA therapy 7–10 days before surgery.^{5,6}

In our cohort, too, ASA was discontinued quite early; 8.9 ± 5.9 days before the operation. Considering the pharmacokinetics of ASA, patients might have been in a normal thrombotic state in the perioperative period. For this reason we performed a subgroup analysis on all ASA users in which we compared bleeding events in patients discontinuing ASA for < 7 days and ≥ 7 days. On average, ASA was discontinued 1 ± 1.4 days before surgery and resumed 3.3 ± 1.3 days after surgery in the patients in whom ASA was discontinued < 7 days, and still no increase of bleeding events was observed. Even though this group of patients showed a significantly higher need for transfusion of PBC and lower postoperative Hb values, this did not correlate with higher morbidity or worse outcome. Clearly the sample size is too small, especially in ASA Group 1 ($n = 4$), to draw a clear conclusion from this subgroup analysis. However, it seems that the continuation of ASA treatment throughout the perioperative period does not lead to more bleeding events.

Association Between ASA Treatment and Thromboembolic Events After VP Shunt Placement

According to the literature, perioperative discontinuation of ASA treatment in patients at risk leads to more cardiovascular complications (9% vs 1.6%)⁹ and a higher odds ratio for an adverse cardiac event (OR 3.14).¹ In addition, the cessation of antiplatelet therapy in patients undergoing intracranial stent procedures showed a hazard ratio of 57 for in-stent thrombosis and led to mortality rates of 45%.¹⁶ In our cohort, there was no significant difference for thromboembolic complications between ASA users and nonusers (2.5% vs 0) and between the ASA Group 1 and Group 2 patients (0 vs 2.8%). However, because the primary goal of our study was to investigate the effect of ASA on bleeding events and due to the retrospective nature of the study, our patients were not routinely screened for thromboembolic events.

Implications of Our Results for Daily Practice

Decision making regarding the perioperative management of patients receiving low-dose ASA treatment who are undergoing VP shunt placement remains a frequently encountered dilemma. Neurosurgeons have to carefully balance the thromboembolic and bleeding risks when trying to handle antithrombotic medication in the perioperative period. Clearly, the indication for ASA treatment represents one of the most important factors guiding the surgeon whether and when to discontinue this medication. In our cohort, ASA treatment in general as well as ASA discontinuation for < 7 days did not lead to increased bleeding rates. Although in patients discontinuing ASA treatment for < 7 days a significantly higher number of PBC units was administered intraoperatively and lower postoperative Hb values were seen, clear conclusions cannot be drawn due to the small sample size. Because in the setting of primary CAD, prophylactic ASA does not seem to affect perioperative cardiovascular-related mortality,^{6,11} ASA discontinuation for ≥ 7 days seems reasonable. As for secondary CAD prevention, where the benefits of ASA treatment are well known,^{6,11} and considering our results, ASA withdrawal for < 7 days might be justified.

Study Limitations

This retrospective study is subject to all the limitations of data collection inherent in such works. Discontinuation of ASA was based on the surgeon's decision, creating a selection bias that is unavoidable in the retrospective setting, because the indication for ASA therapy always played a role in the decision making on how to manage these patients. Hemoglobin values 1–2 days postoperatively might be unreliable due to ongoing rebalancing of intra- and extravascular fluids and to fluid management during and after surgery, and might be influenced by individual factors such as cardiac and renal function. An ASA function test was not conducted routinely, and therefore the effect of ASA treatment on each individual is not known. Last, hospitalization time was relatively long (approximately 15 days), probably due to our heterogenic cohort including patients with various severe neurological conditions (e.g., aSAH and trauma).

Conclusions

Patients receiving low-dose ASA treatment seem to have comparable rates of bleeding events after the placement of a VP shunt to patients without ASA treatment.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Kamenova, Soleman. Acquisition of data: Kamenova, Croci. Analysis and interpretation of data: Kamenova, Soleman. Drafting the article: Kamenova. Critically revising the article: Guzman, Mariani, Soleman. Reviewed submitted version of manuscript: Croci, Soleman. Approved the final version of the manuscript on behalf of all authors: Kamenova. Administrative/technical/material support: Kamenova, Mariani. Study supervision: Kamenova, Soleman.

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