University of Groningen

The Risk of Complications after Carpal Tunnel Release in Patients Taking Acetylsalicylic Acid as Platelet Inhibition

Kaltenborn, Alexander; Frey-Wille, Stefanie; Hoffmann, Sebastian; Wille, Joern; Schulze, Christoph; Settje, Andreas; Vogt, Peter M.; Gutcke, Andre; Ruettermann, Mike

Published in:
Plastic and Reconstructive Surgery

DOI:
[10.1097/PRS.00000000000006465](https://doi.org/10.1097/PRS.00000000000006465)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2020

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Kaltenborn, A., Frey-Wille, S., Hoffmann, S., Wille, J., Schulze, C., Settje, A., Vogt, P. M., Gutcke, A., & Ruettermann, M. (2020). The Risk of Complications after Carpal Tunnel Release in Patients Taking Acetylsalicylic Acid as Platelet Inhibition: A Multicenter Propensity Score-Matched Study. *Plastic and Reconstructive Surgery*, 145(2), 360E-367E. <https://doi.org/10.1097/PRS.00000000000006465>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

The Risk of Complications after Carpal Tunnel Release in Patients Taking Acetylsalicylic Acid as Platelet Inhibition: A Multicenter Propensity Score–Matched Study

Alexander Kaltenborn,
M.D., M.H.B.A.

Stefanie Frey-Wille, M.D.

Sebastian Hoffmann, M.D.

Jörn Wille, M.D.

Christoph Schulze, M.D.

Andreas Settje, M.D.

Peter M. Vogt, M.D.

André Gutcke, M.D.

Mike Ruettermann, M.D.

Westerstede, Hannover, Rostock, and
Oldenburg, Germany; and Groningen,
The Netherlands

PATIENT
SAFETY

Carpal tunnel release is one of the most frequently performed operative procedures in hand surgery. Approximately 400,000 procedures for carpal tunnel syndrome are performed in the United States per year.¹

From the Department of Trauma, Orthopedic, Plastic, Reconstructive, and Hand Surgery, Federal Armed Forces Hospital Westerstede; the Department of Plastic, Aesthetic, Hand, and Reconstructive Surgery, Hannover Medical School; the Department of Orthopedics, University Medicine Rostock; the Institute of Hand and Plastic Surgery Oldenburg; and the Department of Plastic Surgery, University Medical Centre Groningen, University of Groningen.

Received for publication February 12, 2019; accepted June 18, 2019.

The first two authors contributed equally to this article.

Copyright © 2019 by the American Society of Plastic Surgeons

DOI: 10.1097/PRS.0000000000006465

Background: Carpal tunnel release is one of the most common procedures in hand surgery. There is only scarce evidence regarding whether platelet inhibitors increase the risk of developing postoperative hemorrhage in carpal tunnel release.

Methods: This is a multicenter, propensity score–matched study including 635 carpal tunnel releases in 497 patients. Multivariate regression models were adjusted with the propensity score, which was developed to mitigate differences in patients with and without platelet inhibition with acetylsalicylic acid. Propensity score matching provides results close to the statistical quality of randomized controlled trials. The primary study endpoint was postoperative bleeding complication, defined as acute bleeding leading to reoperation or hematoma leading to physician visit. Patient satisfaction, functional outcome measured with the Boston Carpal Tunnel Questionnaire, and onset of surgical-site infection were also analyzed.

Results: Bleeding complications were observed in 56 procedures (8.8 percent). After propensity score matching, there was no significant difference between the patients with and without acetylsalicylic acid treatment ($p = 0.997$). History of thyroid disease ($p = 0.035$) and of rheumatoid arthritis ($p = 0.026$) were independent risk factors, whereas higher body mass index might have a beneficial effect ($p = 0.006$). Patients with postoperative bleeding had significantly impaired functional outcome as measured with the Boston Carpal Tunnel Questionnaire ($p = 0.026$). Median satisfaction in the investigated study population was 10 of 10 points and did not differ significantly between the antiplatelet and the non-antiplatelet cohorts ($p = 0.072$).

Conclusion: Carpal tunnel release under platelet inhibition with acetylsalicylic acid is safe and can be performed without interruption of such medication. (*Plast. Reconstr. Surg.* 145: 360e, 2020.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

With increasing incidences of arteriosclerosis and pulmonary embolisms, the number of patients under antithrombotic medication will

Disclosure: The authors have no financial interest to declare in relation to the content of this article. No funding was received for this article.

Related digital media are available in the full-text version of the article on www.PRSJournal.com.

By reading this article, you are entitled to claim one (1) hour of Category 2 Patient Safety Credit. ASPS members can claim this credit by logging in to PlasticSurgery.org Dashboard, clicking “Submit CME,” and completing the form.

probably increase notably within the next years. Both acetylsalicylic acid and clopidogrel inhibit platelet function irreversibly through inhibition of cyclooxygenase-1 and the adenosine diphosphate receptor, respectively.² There is a notable increase of patients who need carpal tunnel release with concomitant antithrombotic medication in recent years.³

In daily practice, there is wide uncertainty whether platelet aggregation inhibitors should be routinely discontinued during minor elective operative procedures, such as carpal tunnel release. Nevertheless, there are good data from an evidence level II study available and the clinical notion of experienced hand surgeons that there is no necessity to interrupt antiplatelet medication, although evidence from large randomized studies is still scarce and there are no risk-adjusted data available yet.³⁻⁵ It can be hypothesized that the repercussions of interrupting platelet aggregation inhibition, such as thrombotic events, are more likely to occur than surgical complications after surgery under antiplatelet medications. Moreover, these repercussions appear to be much more serious (e.g., stroke, myocardial infarction) than the possible consequences of hemorrhagic complications (e.g., hematoma, postoperative bleeding).

Therefore, the current study investigates whether patients who underwent carpal tunnel release without interruption of platelet inhibition with acetylsalicylic acid have an increased risk for postoperative hemorrhage and hematoma development. Propensity score matching was applied to adjust the compared cohorts for any possible confounder. This approach was recently stated as a method that comes close to the evidence level of randomized controlled trials.⁶⁻⁸ It was further investigated whether the onset of postoperative hemorrhagic complications lead to an impaired outcome after carpal tunnel release.

PATIENTS AND METHODS

This is a multicenter, retrospective, propensity score-matched study including 635 open carpal tunnel releases in 497 consecutive patients, who underwent the procedure between January 1, 2008, and December, 31, 2017, in three hand surgical centers in Germany. Excluded were patients who were operated on under general anesthesia or had additional procedures at the same time as carpal tunnel release (e.g., trigger finger or Dupuytren's surgery). Furthermore, patients taking platelet inhibitors other than acetylsalicylic acid (e.g., clopidogrel) or other

medication that might directly affect postoperative bleeding, such as vitamin K antagonists or direct factor Xa inhibitors, were excluded from analyses. The standard acetylsalicylic acid dose was 100 mg/day, which is the recommended and widely given dose in Germany. This study was outlined and performed in full concordance with the Declaration of Helsinki.

Surgical Technique

The operation is typically performed as an outpatient procedure under local anesthesia with a bloodless field under tourniquet control. Lidocaine 1% with adrenaline 1:200,000 was used in all cases. A 1.5- to 2-cm longitudinal incision was made in the palm along the axis of the radial side of the ring finger from the Kaplan cardinal line and extending proximally toward the wrist flexion crease ulnar to the palmaris longus tendon if present. The subcutaneous fat was bluntly mobilized under protection of the palmar branch of the median nerve. The underlying palmar fascia was incised in line with the skin incision, as was the flexor retinaculum that was opened completely from the mediocarpal fat pad to the restricta (i.e., the beginning of the forearm fascia) under direct vision facilitated by the use of a 4.3-mm nasal speculum. The motor branch of the median nerve was always carefully protected. Any visible bleeding and open vascular lumen was coagulated with bipolar diathermy. The incision was closed with nonabsorbable monofilament 4-0 suture in simple interrupted technique. All patients received a base layer of ointment dressing with cotton padding and gauze bandage on top. There was no splinting applied, postoperatively. In all three study centers, this technique has been the standard method for carpal tunnel release since 2008, and the procedures were carried out by four hand surgeons with experience level III according to Tang and Giddins, which is defined as "an experienced surgeon who has obtained appreciable experience in use of the relevant technique(s), having practiced as a specialist over a longer period (typically > 5 years)."⁹

Study Endpoints

The primary study endpoint was the onset of postoperative bleeding complications. Relevant bleeding leading to reoperation, or hematoma in the operated area larger than 5 cm at the time of the planned postoperative visit in our outpatient clinic within the first 7 days after the procedure, were defined as bleeding complications.

Secondary study endpoints were patient satisfaction measured by means of a visual analogue scale from 0 to 10, functional outcome measured with the Boston Carpal Tunnel Questionnaire, and onset of surgical-site infection.¹⁰ A letter with the visual analogue scale and Boston Carpal Tunnel Questionnaire was sent to a total of 678 consecutive patients, of which 181 (26.7 percent) did not respond. These patients were defined as lost to follow-up; thus, 497 included patients remained as the study population.

Statistical Analysis

Consecutive data were presented as mean and standard deviation if normally distributed and median and range if not normally distributed. Normal distribution was assessed by application of the Kolmogorov-Smirnov test. Normally distributed data were compared with paired two-sided *t* tests. The Mann-Whitney *U* test was applied for comparison of nonparametric data.

Possible risk factors for impaired outcome of carpal tunnel release were identified by univariate binary logistic regression analyses applying an alpha level of 0.20. Thus, all variables with a value of $p < 0.20$ were included in multivariate regression analyses. In multivariate analyses, a value of $p < 0.05$ was defined as statistically significant. The Hosmer-Lemeshow test was applied to evaluate goodness-of-fit of the regression models, indicating good model fit at a value of $p > 0.05$.¹¹ Furthermore, multivariate principal component analysis was applied to identify independent risk factors for impaired outcome. In this graphic analysis, the effects of evaluated variables on the study endpoint are depicted as diverging vectors, which imply statistical independence in the multivariate model.¹²

Propensity score adjustment was performed to mitigate the lack of randomization in the study population; thus, the analysis takes differences in the patient cohorts treated with antiplatelet medication versus without such therapy into account. A propensity score is a statistical matching estimator, which is a suitable tool to assess the effect of a specific factor or treatment on outcome.¹³ The thus stratified effect can be included in further analysis, and the observational data can be matched or adjusted with this estimator.¹³ Propensity scores were developed using the logit link function based on covariates in the multivariate binary logistic regression model, with antiplatelet medication as the dependent variable. The propensity scores were then included into multivariable modeling

of the study endpoints to adjust the study population regarding necessity of antiplatelet therapy for age, preoperative comorbidities, and sex. The results were controlled by performing a backward logistic regression analysis and were reported as odds ratios with 95 percent confidence intervals and corresponding *p* value.¹⁴ Only significant predictors and the propensity score were included in final models rather than all available covariates to minimize the risk of model misspecification from overfitting.¹⁵ Propensity score adjustment is known to provide results that come close to the statistical quality of randomized controlled trials.^{7,8,13} IBM SPSS Version 22.0 (IBM Corp., Armonk, N.Y.) was used to perform statistical analysis.

RESULTS

Six hundred thirty-five carpal tunnel release procedures in 497 patients were included in data analysis; thus, 138 patients (21.7 percent) were treated on both wrists. No patient underwent surgery on both wrists simultaneously. The minimal time between the operations on both wrists was 5 months. All included patients were seen in the outpatient clinic 1 week after the procedure to assess short-term outcome. Long-term outcome such as Boston Carpal Tunnel Questionnaire score and patient satisfaction were assessed at 35.9 ± 34.4 (mean $\pm$ SD) months postoperatively.

Table 1 summarizes the descriptive statistics of the study population and the statistical comparison of the two cohorts treated either with acetylsalicylic acid [$n = 90$ (14.2 percent)] or without such therapy [$n = 545$ (85.8 percent)].

Bleeding Complications after Carpal Tunnel Syndrome Surgery

Overall, bleeding complications after carpal tunnel syndrome surgery were observed in 56 cases (8.8 percent), defined as acute bleeding leading to reoperation [$n = 5$ (0.8 percent)] or hematoma leading to physician visit [$n = 51$ (8.0 percent)]. There was no statistically significant difference in the rate of bleeding complications between patients taking acetylsalicylic acid and those without such therapy in the propensity score-adjusted analysis ($p = 0.997$). In propensity score-adjusted multivariable analysis, history of thyroid disease ($p = 0.035$; OR, 17.400; 95 percent CI, 1.218 to 248.550) and history of rheumatoid arthritis ($p = 0.026$; OR, 12.844; 95 percent CI, 1.363 to 121.044) could be revealed as independent risk factors for the onset of bleeding complications, whereas higher body mass index might

Table 1. Descriptive Data

Variable	<i>p</i> *	Platelet Inhibition (% of Cohort)	No Platelet Inhibition (% of Cohort)	Study Population (% of CTR)
No.		90	545	635
Preoperatively				
Age†	<0.001‡	77 (48–94)	61 (23–95)	65 (23–95)
Male patient	<0.001§	48 (53.3%)	167 (30.6%)	215 (33.9%)
Dominant hand operated	0.280§	46 (51.1%)	301 (55.2%)	347 (54.7%)
History of smoking	0.118§	10 (11.1%)	95 (17.4%)	105 (16.5%)
Diabetes mellitus	<0.001§	34 (37.8%)	55 (10.1%)	89 (14.0%)
Insulin-dependent diabetes	0.004§	11 (12.2%)	25 (4.6%)	36 (5.7%)
Thyroid disease	0.338§	14 (15.6%)	106 (19.5%)	120 (18.9%)
Rheumatoid arthritis	0.332§	16 (17.8%)	75 (13.8%)	91 (14.3%)
Peripheral artery disease	<0.001§	8 (8.9%)	6 (1.1%)	14 (2.2%)
Chronic renal disease	0.020§	4 (4.4%)	6 (1.1%)	10 (1.6%)
Time of preoperative complaints, mo†	0.007‡	12 (1–60)	18 (1–192)	15 (1–192)
Body mass index, kg/m ² †	0.056‡	28 (21–59)	27 (22–62)	27 (21–62)
BCTQ result preoperatively¶	0.032‡	2.1 (0.76)	2.4 (0.80)	2.4 (0.80)
Postoperative				
Bleeding complication	0.073§	14 (15.6%)	42 (7.7%)	56 (8.8%)
Surgical-site infection	0.443§	6 (6.7%)	25 (4.6%)	31 (4.9%)
BCTQ results postoperatively†	0.803‡	0.1 (0–2.7)	0.9 (0–3.9)	0.9 (0–3.9)
Patient satisfaction (VAS 0–10 points)†	0.072‡	9.5 (1–10)	10 (0–10)	10 (0–10)

CTR, carpal tunnel release; BCTQ, Boston Carpal Tunnel Questionnaire; VAS, visual analogue scale.

*The *p* values are basing on the statistical comparison of the cohorts under antiplatelet medication versus no such therapy.v

†Median (range).

‡Mann-Whitney *U* test.§Pearson χ^2 test.

¶Mean (SD).

have a beneficial effect ($p = 0.006$; OR, 0.806; 95 percent CI, 0.692 to 0.939) (Table 2). (See Figure, Supplemental Digital Content 1, which shows the results of multivariable principal component analysis. It can be observed that there is a relevant colinearity between body mass index and history of thyroid disease. There are no vectors pointing in the same direction; therefore, all investigated variables in the multivariable binary regression analysis are independent from each other,

except body mass index and a history of rheumatoid arthritis. Moreover, there is no colinearity between the investigated factors. Application of platelet aggregation inhibitors and the propensity score have a slight trend toward the same vector, because the propensity score matches patients with and without such medication. BMI, body mass index, <http://links.lww.com/PRS/D901>.) All investigated variables show no colinearity with the calculated propensity score or the application of

Table 2. Factors Affecting Bleeding Complications after Carpal Tunnel Release in Propensity Score–Adjusted Analyses

Variables	Univariable Binary Logistic Regression		Multivariable Binary Logistic Regression	
	<i>p</i>	OR (95% CI)	<i>p</i>	OR (95% CI)
Age	0.104		0.703	n.a.
Male sex	0.497			
Operated in dominant hand	0.304		n.i.	
History of smoking	0.198		0.954	n.a.
Diabetes mellitus	0.997			
Insulin-dependent diabetes	0.998	n.a.	n.i.	
Thyroid disease	0.042	6.462 (1.068–39.108)	0.035	17.400 (1.218–248.550)
Rheumatoid arthritis	0.018	8.767 (1.445–53.200)	0.026	12.844 (1.363–121.044)
Peripheral artery disease	0.999			
Chronic renal disease	0.999			
Time of preoperative complaints (mo)	0.839	n.a.	n.i.	
Body mass index	0.006	0.871 (0.790–0.961)	0.006	0.871 (0.790–0.961)
BCTQ result preoperatively	0.916		n.i.	
Antiplatelet therapy	0.997		0.997	
Propensity score adjustment	0.108	n.a.	0.710	n.a.

BCTQ, Boston Carpal Tunnel Questionnaire; n.a., not applicable; n.i., not included in multivariable model.

antiplatelet medication; thus, its possible influence is independent from each other.

Risk Factors for Surgical-Site Infection after Carpal Tunnel Syndrome Surgery

Surgical-site infection was observed after 31 carpal tunnel release procedures (4.9 percent). The development of surgical-site infection was not associated with postoperative bleeding complications as defined in the study protocol ($p = 0.608$). All investigated variables showed no correlation with the development of surgical-site infection; thus, no significant independent risk factor could be revealed in regression analysis ($p > 0.05$). There was no significant difference between the rate of surgical-site infection in the antiplatelet treated cohort and the non-antiplatelet cohort in propensity score-adjusted regression analysis ($p = 0.378$).

Patient Satisfaction after Carpal Tunnel Syndrome Surgery

Median satisfaction in the investigated study population was 10 of 10 points on a visual analogue scale (range, 0 to 10), and it did not differ significantly between the antiplatelet and the non-antiplatelet cohorts (9.5 versus 10; $p = 0.072$) (Table 1).

Functional Outcome as Depicted with the Boston Carpal Tunnel Questionnaire

Postoperative Boston Carpal Tunnel Questionnaire scores between patients under antiplatelet therapy and those without were not significantly different ($p = 0.803$). Overall, the Boston Carpal Tunnel Questionnaire score was drastically reduced by carpal tunnel release in the investigated study population, showing an excellent functional outcome postoperatively (Table 1). Patients who suffered from bleeding complications after carpal tunnel release had significantly worse results in the postoperative Boston Carpal Tunnel Questionnaire ($p = 0.026$; Mann-Whitney U test).

DISCUSSION

Platelet Inhibition and Outcome after Carpal Tunnel Release

The observed complication rate of 8.8 percent is comparable to the recent literature.⁴ Strikingly, this study shows in a large population of almost 500 patients and over 600 performed carpal tunnel release procedures that open carpal tunnel release with a minimally invasive short incision

in patients under platelet inhibitor therapy is safe and can be performed without interruption. It further provides evidence from multivariate, adjusted analyses on significant independent risk factors for impaired outcome.

Current Evidence and Clinical Relevance

Application of platelet aggregation inhibitors is commonly associated with a group of patients with higher age and a multimorbid profile, including diabetes, atherosclerosis, or renal disease. This could be confirmed in the current study (Table 1). Because of these vastly differing clinical characteristics between patients with and without antiplatelet medication, a comparison of these two cohorts is methodologically challenging. Avoiding bias by possible confounders is essential. Matching of multivariate analyses by means of the propensity score in the current study allowed the identification of relevant risk factors beyond these known differences between the two cohorts. As already mentioned, propensity score adjustment is able to provide results, which come close to the statistical quality of randomized controlled trials.^{6,7,13}

A review from Sardenberg and colleagues published in 2017 shows that there are only four studies available on the relevance of platelet inhibitors in hand surgery.⁴ All these studies lack risk adjustment to possible confounders, in contrast to the current study.

In their prospective trials, Edmunds and Avakian and Bogunovic and colleagues reported one case of severe postoperative bleeding each.^{3,16} In both cases, the patient had rheumatoid arthritis. The prospective study of Bogunovic and colleagues especially showed very promising results regarding the application of platelet aggregation inhibitors during carpal tunnel release; however, no patients after endoscopic or minimally invasive open carpal tunnel release were included in this study and, overall, only 214 patients were analyzed.³ Furthermore, the analysis was not controlled for confounding differences between the cohorts with and without antiplatelet medication.

Boogaarts et al. conducted a retrospective study in 2010, reporting no complications, although only six patients under platelet inhibitors were analyzed.¹⁷ In 2013, a Swiss group reported their results comparing 50 patients each with versus without platelet inhibitors during carpal tunnel release.⁵ They only describe the follow-up of these cohorts and do not include a statistical analysis or risk adjustment for possible confounders; thus, there is a high risk of statistical bias.

Considered together, all evidence points in the direction that platelet inhibitors might be continued during carpal tunnel release. However, the current literature is flawed because of the possible influence of multiple confounders. Therefore, this interesting and relevant clinical issue is not solved yet, and a responsible evidence-based decision has not been possible. Because of its unique methodology, the current data not only support the assumptions of previous studies, they also deliver evidence beyond possible confounders. They further add new evidence on significant independent risk factors for the onset of postoperative bleeding complications.

Furthermore, the current study also provides evidence that the onset of such bleeding complications influences the functional outcome after carpal tunnel release significantly as measured by means of the Boston Carpal Tunnel Questionnaire ($p = 0.026$). Therefore, bleeding complications are a relevant and warranted aim to optimize surgical care for patients suffering from carpal tunnel syndrome.

Relevance of Rheumatoid Arthritis

Rheumatoid arthritis was identified as an independent risk factors for the development of bleeding complications ($p = 0.026$). Long-term medication in patients suffering from rheumatoid arthritis is known to influence the tissue texture through alteration of many intracellular and extracellular mechanisms.^{18,19} Medications with corticosteroids, methotrexate, or biologicals are known to lead to more tissue susceptibility to damage, resulting in problems with wound healing, especially when these medications have been used over a longer period.^{20,21} This is the case in patients suffering from rheumatoid arthritis. Thus, it is not surprising that these patients are prone to postoperative hemorrhage.

Relevance of Thyroid Disease

Patients suffering from thyroid disease were identified to have a significantly increased risk of developing bleeding complications after carpal tunnel release ($p = 0.035$). A general association between thyroid disease and hemorrhage is still a matter of controversy and the objective of recent research.^{22–24} It seems to be undoubted that thyroid disorders are correlated with coagulation.²⁴ Both thyroid dysfunction and autoimmunity may modify physiologic processes of primary and secondary hemostasis and lead to bleeding and thrombosis.²⁵ In a systematic review, Squizzato and

colleagues concluded that dysfunctional thyroid diseases, hypothyroidism and hyperthyroidism, overt and subclinical, alter the coagulation-fibrinolysis balance; in detail, hypothyroidism seems to be especially associated with an increased risk of bleeding.²⁵ In this context, it is assumed that thyroid hormones play a direct role in hemostasis.^{23–25} Human in vivo studies reported evidence that a lack of thyroid hormones, even in subclinical disorders, leads to decreased plasma levels and inhibited activity of factor VIII and von Willebrand factor.^{26,27} Furthermore, increased fibrinolysis because of reduced antifibrinolytic factors was also observed in these studies.²⁷ Especially hypothyroidism seems to shift the balance between coagulation and fibrinolysis to a hypocoagulable state, possibly leading to the risk of postoperative bleeding as observed in the current study.

Effect of Body Mass Index

The shown protective effects of an elevated body mass index in propensity score-adjusted analysis regarding the onset of hemorrhagic complications after carpal tunnel release cannot be fully explained retrospectively. It might be that more prominent soft tissues around the operative field are able to prevent the development of hematoma in obese patients, or disguise them. It is further interesting to note that there was no association between an elevated body mass index and the onset of surgical-site infection in the analyzed data, which has been proposed in several earlier studies.^{28–30} This is also the case with nicotine abuse. However, it needs to be kept in mind that surgical-site infection was not the primary study endpoint of this analysis, which might explain these findings.

As depicted (see **Figure, Supplemental Digital Content 1**, <http://links.lww.com/PRS/D901>), there is a colinearity in the underlying data structure, which was observed between the body mass index and history of thyroid disease. It can be hypothesized that in clinical practice there is a relevant coincidence of patients with an elevated body mass index and thyroid disorders. All investigated variables show no colinearity with the calculated propensity score or the application of antiplatelet medication; thus, the multivariable model is valid and the influence of the identified risk factors on the onset of bleeding complications is independent from each other.

Limitations

It is still a matter of controversy whether tourniquet deflation at the end of the procedure with

selective cauterization, or leaving the tourniquet closed until sutures and compressive dressing are applied, with the benefit of tamponade, is the better technique for hematoma avoidance. Unfortunately, the current data are not able to answer this clinical question. The presented results are limited because of the retrospective design of this study. Moreover, patients who might have stopped their regular antiplatelet therapy before carpal tunnel release (e.g., because of recommendation of their general practitioner) could not be identified retrospectively; thus, there might have been some patients in the non-antiplatelet cohort who had just paused their medication for the procedure without notifying the surgeon, even though they were asked whether they did. Moreover, it was not able to assess how long patients have taken platelet inhibitors, retrospectively. Patients taking antiplatelet medications other than acetylsalicylic acid (e.g., clopidogrel) were excluded from this study. On the one hand, this led to a more homogenous study population; on the other hand, the current study provides no insight into this aspect. We therefore suggest further studies to analyze this issue, preferably in a prospective design, which should also take the individual medications for comorbidities into account.

Antiplatelet medication is taken because of medical indications, but the study design is not able to show possible negative repercussions of an interruption on the underlying diseases in the long run. The center bias is minimized by the multicentric design.

CONCLUSIONS

Carpal tunnel release with continued acetylsalicylic acid intake is safe and does not lead to an increased risk of postoperative bleeding complications. This study shows that this finding is independent from other clinical characteristics of the patient, such as comorbidities, sex, age, preoperative duration of complaints, preoperative hand functionality, and smoking habits. Hemorrhagic events were significantly and independently associated with a history of thyroid disorders and of rheumatoid disease. Patients who suffered from postoperative bleeding complications had significantly impaired functional outcome as measured with the Boston Carpal Tunnel Questionnaire. Nevertheless, patient satisfaction was comparable between the platelet-inhibition and the non-platelet-inhibition cohorts.

Alexander Kaltenborn, M.D., M.H.B.A.

Department of Trauma, Orthopedic, Plastic,
Reconstructive, and Hand Surgery
Federal Armed Forces Hospital Westerstede
26655 Westerstede, Germany
kaltenborn.alexander@mh-hannover.de

REFERENCES

1. Ono S, Clapham PJ, Chung KC. Optimal management of carpal tunnel syndrome. *Int J Gen Med*. 2010;3:255–261.
2. Vane JR, Botting RM. The mechanism of action of aspirin. *Thromb Res*. 2003;110:255–258.
3. Bogunovic L, Gelberman RH, Goldfarb CA, Boyer MI, Calfee RP. The impact of antiplatelet medication on hand and wrist surgery. *J Hand Surg Am*. 2013;38:1063–1070.
4. Sardenberg T, Deienno FS, Miranda RF, Varanda D, Cortopassi AC, Silveira PRA. Hand and wrist surgery without suspending warfarin or oral antiplatelet: Systematic review. *Rev Bras Ortop*. 2017;52:390–395.
5. Brunetti S, Petri GJ, Lucchina S, Garavaglia G, Fusetti C. Should aspirin be stopped before carpal tunnel surgery? A prospective study. *World J Orthop*. 2013;4:299–302.
6. Melamed A, Margul DJ, Chen L, et al. Survival after minimally invasive radical hysterectomy for early-stage cervical cancer. *N Engl J Med*. 2018;379:1905–1914.
7. Lauer MS, D'Agostino RB Sr. The randomized registry trial: The next disruptive technology in clinical research? *N Engl J Med*. 2013;369:1579–1581.
8. Blackstone EH. Comparing apples and oranges. *J Thorac Cardiovasc Surg*. 2002;123:8–15.
9. Tang JB, Giddins G. Why and how to report surgeons' levels of expertise. *J Hand Surg Eur Vol*. 2016;41:365–366.
10. Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Joint Surg Am*. 1993;75:1585–1592.
11. Hosmer DW Jr, Lemeshow S, Sturdivant RX. *Applied Logistic Regression*. 3rd ed. New York: Wiley; 2013.
12. Groth D, Hartmann S, Klie S, Selbig J. Principal components analysis. *Methods Mol Biol*. 2013;930:527–547.
13. Kuss O, Blettner M, Börgemann J. Propensity score: An alternative method of analyzing treatment effects. *Dtsch Arztebl Int*. 2016;113:597–603.
14. Ius F, Sommer W, Tudorache I, et al. Preemptive treatment with therapeutic plasma exchange and rituximab for early donor-specific antibodies after lung transplantation. *J Heart Lung Transplant*. 2015;34:50–58.
15. Drake C, Fisher L. Prognostic models and the propensity score. *Int J Epidemiol*. 1995;24:183–187.
16. Edmunds I, Avakian Z. Hand surgery on anticoagulated patients: A prospective study of 121 operations. *Hand Surg*. 2010;15:109–113.
17. Boogaarts HD, Verbeek AL, Bartels RH. Surgery for carpal tunnel syndrome under antiplatelet therapy. *Clin Neurol Neurosurg*. 2010;112:791–793.
18. Barnard AR, Regan M, Burke FD, Chung KC, Wilgis EF. Wound healing with medications for rheumatoid arthritis in hand surgery. *ISRN Rheumatol*. 2012;2012:251962.
19. Goodman SM. Rheumatoid arthritis: Perioperative management of biologics and DMARDs. *Semin Arthritis Rheum*. 2015;44:627–632.
20. Wang AS, Armstrong EJ, Armstrong AW. Corticosteroids and wound healing: Clinical considerations in the perioperative period. *Am J Surg*. 2013;206:410–417.

21. Pountos I, Giannoudis PV. Effect of methotrexate on bone and wound healing. *Expert Opin Drug Saf.* 2017;16:535–545.
22. Kyriakakis N, Lynch J, Ajjan R, Murray RD. The effects of pituitary and thyroid disorders on haemostasis: Potential clinical implications. *Clin Endocrinol (Oxf.)* 2016;84:473–484.
23. Ordookhani A, Burman KD. Hemostasis in hypothyroidism and autoimmune thyroid disorders. *Int J Endocrinol Metab.* 2017;15:e42649.
24. Elbers LPB, Squizzato A, Gerdes VEA. Thyroid disorders and hemostasis. *Semin Thromb Hemost.* 2018;44:676–682.
25. Squizzato A, Romualdi E, Büller HR, Gerdes VE. Clinical review: Thyroid dysfunction and effects on coagulation and fibrinolysis. A systematic review. *J Clin Endocrinol Metab.* 2007;92:2415–2420.
26. Shih CH, Chen SL, Yen CC, et al. Thyroid hormone receptor-dependent transcriptional regulation of fibrinogen and coagulation proteins. *Endocrinology* 2004;145:2804–2814.
27. Erem C. Thyroid disorders and hypercoagulability. *Semin Thromb Hemost.* 2011;37:17–26.
28. Platt AJ, Mohan D, Baguley P. The effect of body mass index and wound irrigation on outcome after bilateral breast reduction. *Ann Plast Surg.* 2003;51:552–555.
29. Waisbren E, Rosen H, Bader AM, Lipsitz SR, Rogers SO Jr, Eriksson E. Percent body fat and prediction of surgical site infection. *J Am Coll Surg.* 2010;210:381–389.
30. Giordano SA, Garvey PB, Baumann DP, Liu J, Butler CE. The impact of body mass index on abdominal wall reconstruction outcomes: A comparative study. *Plast Reconstr Surg.* 2017;139:1234–1244.