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SYSTEMATIC REVIEW AND META-ANALYSIS

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Unplanned Reoperations in Neurosurgical Patients Due to Postoperative Bleeding

A Single-Center Experience and Literature Review

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Abstract: The aim of this study is to investigate the incidence of unplanned reoperations from all causes due to bleeding in neurosurgical patients.

The medical records of patients who received neurosurgical procedures at our hospital were retrospectively reviewed and data of patients who received reoperations were extracted and summarized. A literature review was conducted of the Medline, Cochrane, EMBASE, and Google Scholar databases up to November 2013. The main outcome measure was the rate of unplanned reoperations due to bleeding.

At our hospital, 68 patients with a mean age of 41.5 ± 21.5 years (range, 7 months to 76 years) received an unplanned reoperation. More than 70% of the patients were older than 18 years, 64.7% were males, and 94.1% had cranial surgery. Almost 60% of the patients received >1 blood transfusion (58.8%) after the first surgery. Of the 68 patients, 35 (51.5%) received a second operation due to bleeding. Univariate logistic regression analysis only showed that an increasing time interval between the first and second surgery was associated with a decreased chance of the reoperation being performed due to bleeding (odds ratio [OR] = 0.843, 95% confidence interval [CI]: 0.720–0.987; $P = .033$). Of 229 studies identified, 5 retrospective reports with a total of 1375 patients were included in the analysis. The rate of reoperations for bleeding in the 5 studies ranged from 4.2% to 31.5%.

Employing measures to reduce postoperative bleeding may help reduce the rate of unplanned neurosurgical reoperations.

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Abbreviations: CI = confidence interval, IQR = inter-quartile range, OR = odds ratio, SAE = surgical adverse event, SD = standard deviation.

INTRODUCTION

A large proportion of preventable adverse events in hospitalized patients occur in patients treated surgically.[1–3] The percentage of preventable adverse events that are experienced by surgical patients has been reported to range from 48% to 79%.[2] To reduce the incidence of adverse events, and thereby improve the quality of care requires systematic measurement and prospective recording.[1–4] However, in general practice, there is a lack of appropriate systematic measures.[1] Mortality is too rare to be used as such a measure, and nonfatal complications are often associated to such a large degree with specific procedures that they would not be useful as a measure for wide application to general surgical procedures.[1]

There have been suggestions that unplanned reoperations, being relatively nondiscretionary and discrete events, might be useful as a quality of care indicator.[1–5] Tracking the rate of unplanned reoperations in surgical patients has been used as an indicator of quality of care in some European countries.[4,6] This measure has the advantage of being broadly applicable because it can occur following almost any surgical procedure.[1]

The incidence of unplanned reoperations has been used as a metric in a number of surgical disciplines,[5–9] and is related to mortality in some patient populations.[9,10] However, there have been few studies examining its used with respect to neurosurgical procedures.[2,11] Because in many cases an unplanned reoperation is performed for bleeding complications, the rate of unplanned neurosurgical reoperations for bleeding might be used as a quality of care indicator.

This retrospective study was performed to determine the incidence of unplanned reoperations from all causes and due to bleeding in neurosurgical patients treated at our institution, and review the literature for studies that examined unplanned reoperations in neurosurgical patients to provide data for comparison.

MATERIALS AND METHODS

Hospital Record Review

The medical records of patients who received neurosurgical procedures at our hospital were retrospectively reviewed. Data extracted from the records included participants' age and sex, diagnosis of patients, type of surgery performed, reason for unplanned return to the operating room, number of unplanned reoperations, number of unplanned reoperations due to bleeding, and surgical adverse events. This study was approved by the Institutional Review Board of our hospital, and because of the retrospective nature of the study, the requirement of informed patient consent was waived.

Outcome Measures and Statistical Analysis

The primary outcome measures were the rate of unplanned reoperations from all causes and the rate of unplanned reoperations due to bleeding. Patient characteristics were summarized

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as mean ± standard deviations (SD) with range for continuous data and number (percentage) for categorical data. For determining the association of postoperative bleeding with patient characteristics, patient data were represented as number (%) or median with interquartile range (IQR). Univariate binary logistic regression analysis was used to identify patient characteristics that might be associated with postoperative bleeding requiring reoperation. Results were presented as odds ratio (OR) with corresponding 95% confidence intervals (95% CI) and *P* value. Statistical analyses were performed using SPSS 15.0 statistics software (SPSS Inc, Chicago, IL). Statistical assessments were 2-tailed, and a value of $P < 0.05$ was considered to indicate statistical significance.

Literature Search Strategy and Selection Criteria

The Medline, Cochrane Library, EMBASE, and Google Scholar databases were searched until November 2013 using combinations of the following keywords: neurosurgery, hemorrhage, bleeding, reoperation, return, revision, postoperative, and unplanned surgery. Reference lists of relevant studies were handsearched.

Studies were included if patients who underwent neurosurgery had to return to the operating room due to complications such as bleeding or infection. Case reports and non-English studies were excluded. Studies were identified by the search strategy by 2 independent reviewers. Where there was uncertainty regarding eligibility, a third reviewer was consulted and the decision for inclusion was arrived at by consensus.

Data Extraction

The following data were extracted from studies that met the inclusion criteria: name of the first author, year of publication, study design, number of participants in each group, participants' age and sex, diagnosis of patients, type of surgery performed, reason for unplanned return to the operating room, number of unplanned reoperations, number of unplanned reoperations due to bleeding, and surgical adverse events.

Quality Assessment

Each study was assessed for quality by using an 18-item modified Delphi checklist, which is a validated tool for assessing the quality of an observational study, including potential bias, with no control group.[12] This checklist includes quality control measures such as a clearly stated hypothesis, follow-up data, eligibility standards, and length of follow-up.

RESULTS

Hospital Record Review

A total of 68 neurosurgical patients received an unplanned reoperation at our hospital, and their characteristics are summarized in Table 1. The mean age of the patients was 41.5 ± 21.5 years (range, 7 months–76 years). More than 70% of the patients were older than 18 years, 64.7% were males, 94.1% had cranial surgery, and 10.3% had traumatic injuries. The mean time of the first operation was 210.6 min (range, 25–525 min) and 5 patients (7.4%) received anticoagulation. Almost 60% of the patients received >1 blood transfusion (58.8%) after receiving the first operation.

Among the 68 patients who received an unplanned reoperation, 35 (51.5%) received the reoperation due to bleeding and the result of the univariate logistic regression analysis comparing the 2 groups is shown in Table 2. Of the characteristics compared, the only significant difference between the 2 groups was the interval between the first surgery and the reoperation. Reoperations due to bleeding occurred

TABLE 1. Characteristics of the 68 Patients Who Received an Unplanned Reoperation at our Center

Age, y	41.5 ± 21.5
0–18	16 (23.5)
19–65	42 (61.8)
≥65	10 (14.7)
Sex	
Male	44 (64.7)
Female	24 (35.3)
Number of hospitalizations	
1	58 (85.2)
2	8 (11.8)
3	1 (1.5)
4	1 (1.5)
Length of hospitalization, days	21.6 ± 10.9 (3, 55)
Severity at hospitalization	
0 (mild)	25 (36.8)
1 (Moderate)	2 (2.9)
2 (Severe)	41 (60.3)
Number of blood transfusions	
0	28 (41.2)
1	20 (29.4)
2–10	20 (29.4)
Amount of blood transfusion, mL (n = 40)	1202 ± 1142 (240, 6840)
Time interval between 1st and 2nd operation, hours	4.22 ± 4.55 (1, 23)
Surgery type	
Cranial	64 (94.1)
Spinal	4 (5.9)
Traumatic injury	
Yes	7 (10.3)
No	61 (89.7)
Elective vs emergency	
Elective	59 (86.8)
Emergency	9 (13.2)
Cardiovascular disease	
Yes	15 (22.1)
No	53 (77.9)
Length of 1st operation, min	210.6 ± 109.6 (25, 525)
ASA score	
1	2 (2.9)
2	37 (54.4)
3	22 (32.4)
4	7 (10.3)
Using anticoagulated vs normal clotting (1st operation)	
Normal clotting	63 (92.6)
Anticoagulated clotting	5 (7.4)
Reason for 2nd operation	
Bleeding	35 (51.5)
Other	33 (48.5)
Using anticoagulated vs normal clotting (2nd operation)	
Normal clotting	68 (100)
Anticoagulated clotting	0 (0)
Follow-up status	
Improved	11 (16.2)
Cured	41 (60.3)
Failed	8 (11.8)
Death	7 (10.3)
Other	1 (1.5)

Data are presented as mean ± standard deviation (range) or number (percentage). ASA = American Society of Anesthesiologists.

TABLE 2. Univariate Analysis of Factors Associated With an Unplanned Reoperation at our Center

Characteristic	Unplanned Reoperation Due to Bleeding	Unplanned Reoperation due to a Cause Other Than Bleeding	*P*
Age, y			
0–18	8 (50)	8 (50)	
19–65	21 (50)	21 (50)	1.000
≥65	6 (60)	4 (40)	0.619
Sex			
Female	14 (58.3)	10 (41.7)	
Male	21 (47.7)	23 (52.3)	0.404
Length of hospitalization, days	22 (16, 31)	20 (10, 28)	0.155
Severity at hospitalization			
0	13 (52)	12 (48)	
1	1 (50)	1 (50)	0.957
2	21 (51.2)	20 (48.8)	0.951
Number of blood transfusions			
0	11 (39.3)	17 (60.7)	
1	13 (65)	7 (35)	0.083
2–10	11 (55)	9 (45)	0.284
Amount of blood transfusion, mL (n = 40)	1025 (522.5, 1602.5)	900 (442.5, 1187.5)	0.112
Time interval between 1st and 2nd operation. days	2 (1, 4)	4 (2, 7)	0.033*
Surgery type			
Cranial	35 (54.7)	29 (45.3)	
Spinal	0 (0)	4 (100)	
Traumatic injury			
No	31 (50.8)	30 (49.2)	
Yes	4 (57.1)	3 (42.9)	0.752
Elective vs emergency			
Elective	30 (50.8)	29 (49.2)	
Emergency	5 (55.6)	4 (44.4)	0.793
Cardiovascular disease			
No	8 (53.3)	7 (46.7)	
Yes	27 (50.9)	26 (49.1)	0.870
Length of first operation, min	180 (135, 245)	180 (145, 300)	0.423
ASA score			
1	0 (0)	2 (100)	
2	22 (59.5)	15 (40.5)	
3	8 (36.4)	14 (63.6)	0.090
4	5 (71.4)	2 (28.6)	0.554
Using anticoagulated vs normal clotting (1st operation)			
Normal clotting	32 (50.8)	31 (49.2)	
Anticoagulated clotting	3 (60)	2 (40)	0.693

Categorical data were presented as number (%) and continuous data without a normal distribution as median with interquartile range (IQR). Univariate binary logistic regression was performed for determined the association of a second operation due to bleeding and patient data. ASA = American Society of Anesthesiologists, CI = confidence interval, OR = odds ratio.

* $P < .05$, indicates significant association.

significantly earlier than reoperations due to other causes ($P = 0.033$).

Literature Review

A flow diagram of study selection is shown in Figure 1. A total of 229 studies were initially identified, and of these 13 full-text articles were reviewed. Of the 13 articles, 8 were excluded and 5 were included in the review.[2,13–16]

The 5 studies included in the review were retrospective studies, and they are summarized in Tables 3 and 4. The number of patients ranged from 95 to 879, and the total number of patients was 1375. The age of the patients ranged from 1 month to >80 years. The reasons for unplanned reoperations included infection, hemorrhage, seizure, brain edema, hematoma, ischemia, cerebellar hemorrhage, tension pneumocephalus, compression of internal carotid arteries, subarachnoid hemorrhage and intracerebral hematoma, and shunt malfunction. Among the 1375 patients, there were 211 (15.3%) unplanned reoperations; however, the study by Lau et al[13] did not report the total number of unplanned reoperations (only the number due to bleeding were reported). Of the 211 reoperations, 64 (30.3%) were due to bleeding (Table 4). The rate of reoperations for bleeding in the 5 studies ranged from 4.2% to 31.5%

Adverse events that occurred during the unplanned reoperations included infection, fever, laryngitis, hypothermia, ataxia, severe disability or vegetative state, mortality due to extensive stroke, mild right hemiparesis, ischemia, and cross motor slight dyscoordination.

The results of Delphi quality assessment of these 5 studies are shown in Table 5. The 5 studies were generally of high quality with low risk of bias.

DISCUSSION

To our knowledge, this is the first study to focus on the rate of reoperations due to bleeding in neurosurgical patients. The

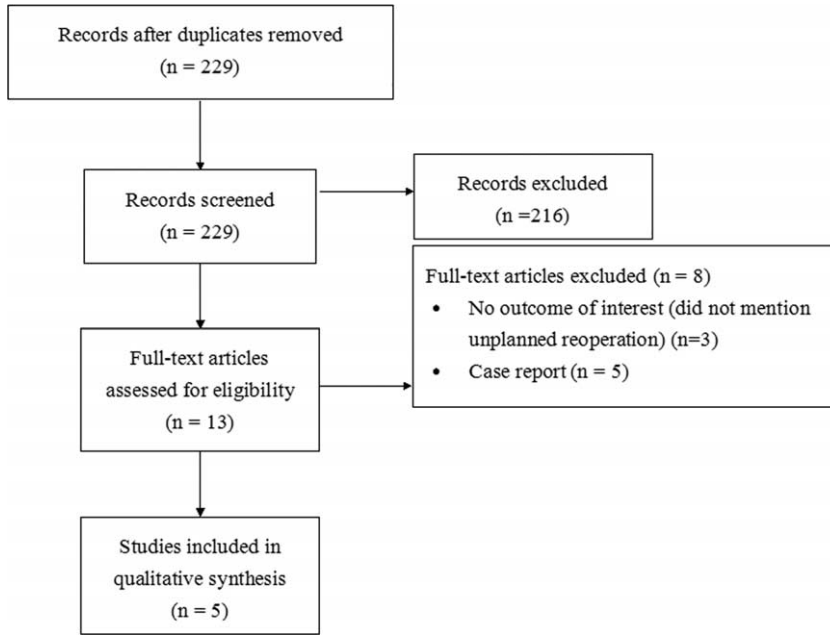

FIGURE 1. Flow Diagram of Study Selection.

analysis of data from our hospital indicated that the time interval between the first operation and the reoperation was significantly shorter when the reoperation was performed due to bleeding than when it was performed for other causes. This type of information might be useful as an indicator of surgical quality of care, and alert surgeons that the different complications might occur at different post-operative time points, and thus assist in diagnosis and treatment.

Comparing the series from our hospital with those included in the literature review, though a formal statistical analysis was not performed, patient age, sex distribution, diagnoses, surgical procedures performed, and the reasons for the unplanned reoperations were not dissimilar. Importantly, however, the rate of unplanned neurosurgical reoperations due to bleeding in the literature ranged from 4.2% to 31.5%, and the rate at our hospital during the study period was 51.5%. As the rate at our hospital was markedly greater than that reported in the literature, these data and the results of this analysis will be used to improve the quality of care and reduce the rate of unplanned neurosurgical reoperations at our hospital. Unplanned reoperations are relatively uncommon,[3] although the incidence varies greatly with reports ranging from 0.6% to 9.4%.[4] Examining the incidence of unplanned reoperations provides a number of potential advantages as an indicator of the quality of care. The number of procedures is relatively easy to identify by using administrative or clinical data.[3] Because unplanned

TABLE 3. Characteristics of Studies Included in the Systematic Review

1st author	Year of Publication	Type of Study	Number of Patients	Age, y	Sex, Male	Diagnosis
Marini[2]	2012	Retrospective	879	53.7 ± 0.8	50%	Not stated
Lau[13]	2012	Retrospective	103	>80 (27 patients) ≤80 (76 patients)	58%	Closed head trauma: intracranial hemorrhage and hematoma requiring evacuation
Mekitarian Filho[14]	2011	Retrospective	198	24.5 (1, 187)* mo	56.6%	Neurosurgical procedures (central or peripheral nervous system); cranial congenital malformations
Chernov[15]	2007	Retrospective	100	46 (19, 73)†	39%	Intracranial tumor
Lund-Johansen[16]	1994	Retrospective	95	63 (16, 85)*	45.3%	Hydrocephalus (normal pressure hydrocephalus, intracranial hemorrhage, tumors, other)
Zheng (current series)	2015	Retrospective	68	41.5 ± 21.5	64.7%	Traumatic injuries, brain tumor, hydrocephalus, congenital malformations, intracranial hemorrhage

Age is presented as mean ± standard deviation.
* Median (range).
† Mean (range).

TABLE 4. Surgeries and outcomes of Studies Included in the Systematic Review

1st author	Type of Surgery Performed	Reasons for Unplanned Reoperation	Number of Unplanned Reoperations	Number of Unplanned Reoperation Due to Bleeding	Surgical Adverse Events
Marini[2]	Brain, spinal, and other	Infection (n = 24), hemorrhage (n = 23), other (n = 26)	73	23 (31.5%)	Infection, hemorrhage, other
Lau[13]	Craniotomy (evacuation of hematoma)	Not reported	14	1 (7.1%)	Infection, hemorrhage, cardio vascular, neurological, other
Mekitarian Filho[14]	Ventriculoperitoneal shunt, craniosynostosis, supratentorial brain tumors, infratentorial brain tumors, dysostosis syndromes, epilepsy surgery, medullary tumors	Infection, bleeding, seizure	Not reported	14	Fever, bleeding, laryngitis, seizure, hypothermia, intracranial hemorrhage, CSF leakage, infection
Chernov[15]	Craniotomy and tumor resection	Brain edema (n = 31), hema toma (n = 25), ischemia (n = 24), local CSF collection (n = 6)	100	25 (25%)	Developed severe disability or vegetative state, death
Lund-Johansen[16]	Ventriculoperitoneal shunt	Shunt malfunction (n = 17), complications with primary implantation (n = 7)	24	1 (4.2%)	Subarachnoid hemorrhage, infection, ischemia
Zheng (current series)	Craniotomy, tumor resection, ventriculoperitoneal shunt	Hematoma or hemorrhage (n = 35), edema (n = 18), intracranial hypertension (n = 8), subdural effusion (n = 2), deep vein thrombosis (n = 1), shunt occlusion (n = 1), wound complications (n = 3)	68	35 (51.5%)	Epidural hematoma, intracranial hemorrhage, death

CSF = cerebrospinal fluid.

reoperations can occur following almost any type of surgical procedure, their use as a metric is widely applicable.[1] Another advantage of examining the incidence of unplanned reoperations is that it provides surgeons with an opportunity to evaluate their performance.[4]

Although the incidence of unplanned reoperations appears to provide a number of advantages as an indicator of quality of care, authors have pointed out the limitations of using data on unplanned operations for internal quality improvement. Birkmeyer et al[1] noted that for any specific procedure, the number of unplanned reoperations is relatively low, making it difficult to determine whether a high rate is due to chance or actual real problems, and it is difficult to the ''acceptable'' reoperation rate, and in addition determining when unplanned reoperations are ''preventable,'' or even if they are related to quality of care presents difficulties. Birkmeyer et al[1] also noted that using the incidence of unplanned reoperations for quality control with regard to general surgery has a number of downsides: differences in patient case-mix across hospitals could present problems for analyses; some reoperation rates might be a reflection of local practice rather than technical competence; and using reoperation rates might be a deterrent to surgeons carrying out timely procedures. Kroon et al[4] noted that before the incidence of unplanned reoperations can be used as an indicator of quality of care, an accurate and complete reoperation registry is necessary and the preoperative patient characteristics need to be correlated with the severity of the index operation. Other authors have also pointed out that an unplanned reoperation is related to the skill and judgment of the surgeon as well as the patient's condition and is thus in part determined by the case mix of the institution.[5,17] Other study of general surgery has shown that a relatively small number of procedures account for a disproportion share of morbidity and mortality and efforts focused on these procedures may improve patient care.[18]

Few studies have specifically focused on neurosurgical reoperations. Marini et al[2] described a pilot study of surveillance of unplanned return to the operating room after neurosurgical procedures using hospital information system payment information. A total of 1006 procedures were included in the analysis and of these a reoperation occurred in 152. In 73 cases, the unplanned reoperation was due to a surgical adverse event (SAE) of which there were 24 infectious SAEs, 23 hemorrhagic SAEs, and 26 SAEs related to other causes. In a recent study, Rolston et al[11] examined data of over 38,000 neurosurgical cases for the years 2006to 2011 acquired from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database. Complications occurred in 14.3% of cases, and cranial cases were 2.6 times more likely to have complications than spine cases. Bleeding requiring transfusion (4.5%) was the most frequent complication and was followed by reoperation within 30 days from the initial surgery (4.3%) and postoperative failure to wean from mechanical ventilation (2.5%). Preoperative stroke, sepsis, blood transfusion, and chronic steroid use were found to be the significant predictors of complications.

There are several limitations to the study. This study determined the incidence of unplanned neurosurgical reoperations because of postoperative bleeding, but as the goal is to reduce postoperative bleeding, there is a need to preoperatively identify patients with an elevated risk for bleeding related to

TABLE 5. Delphi Quality Assessment of the Studies Included in the Systematic Review

1st Author	Year	Is the Hypothesis/ Aim/Objective of the study Clearly Stated in the Abstract, Introduction, or Methods Section?	Are the Characteristics of the Participants Included in the Study Described?	Were the Cases Collected in >1 Centre?	Are the Eligibility Criteria (Inclusion and Exclusion Criteria) to Entry the Study Explicit and appropriate?	Were Participants Recruited Consecutively?	Did Participants Enter the Study at a Similar Point in the Disease?	Was the Intervention Clearly Described in the Study?	Were Additional Interventions (Co-interventions) Clearly Reported in the Study?	Are the Outcome Measures Clearly Defined in the Introduction or Methods Section?
Marini[2]	2012	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Lau[13]	2012	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Mekitarian Filho[14]	2011	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes
Chernov[15]	2007	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Lund-Johansen[16]	1999	Yes	No	No	Yes	Yes	Yes	No	No	Yes
Zheng (current series)	2015	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes

Delphi Quality Assessment (Continued)

1st Author	Year	Were Relevant Outcomes Appropriately Measured With Objective and/or Subjective Methods?	Were Outcomes Measured Before and after Intervention?	Were the Statistical Tests Used to Assess the Relevant Outcomes Appropriate?	Was the Length of Follow-up Reported?	Was the Loss to Follow-up Reported?	Does the Study Provide Estimates of the Random Variability in the Data Analysis of Relevant Outcomes?	Are Adverse Events Reported?	Are the Conclusions of the Study Supported by Results?	Are Both Competing Interest and Source of Support for the Study Reported?
Marini[2]	2012	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Lau[13]	2012	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Mekitarian Filho[14]	2011	Yes	Yes	Yes	Yes	No	Ye	Yes	Yes	Yes
Chernov[15]	2007	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Lund-Johansen[16]	1999	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Zheng (current series)	2015	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

abnormalities of platelet function and coagulation. Both the systematic review and our case series lacked information on the preoperative laboratory examinations of patients. If patients are thoroughly examined before surgery, the frequency of unplanned reoperations might be reduced. The systematic review was limited because the time between the initial operation and the unplanned reoperation was not reported. Examination of the surgeries at our hospital showed that the time interval between the first surgery and reoperation was shorter when the reoperation was performed for bleeding than when it was performed for other causes. As this was a simple retrospective observational study, the risk factors for reoperation cannot be determined with certainty. With respect to the case series, potential recall bias might exist due to the retrospective observational study design. However, we believe the impact of bias is very limited because all of the results were obtained from reviewing the medical charts, and this is not altered by recall or patients' memory. With respect to the literature review, potential bias was evaluated by assessing the quality of the included studies using the 18-item modified Delphi checklist, which is a validated tool for assessing the quality of an observational study with no control group. The included studies were generally of high quality, suggesting that the risk of bias is low.

In conclusion, the incidence of unplanned reoperations after neurosurgical procedures varies considerable and can be high, and in many instances, the reoperation is performed due to bleeding. Employing measures to reduce postoperative bleeding may help reduce the rate of unplanned reoperations, and thereby improve the quality of surgical care.

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