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Original study

Assessment of the incidence and risk factors of postoperative delirium in neurosurgery: A prospective observational study

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Abstract

Objective: **The aim of this study is to assess the incidence of postoperative delirium (POD) in patients over 60 years undergoing neurosurgery at our institution. The secondary objectives are to identify risk factors for POD, focusing on preoperative, intraoperative, and postoperative data.**

Background: **POD is one of the most common postoperative complications. Recent meta-analyses indicate that the incidence of POD following neurosurgery is highly variable, particularly for spinal procedures. Accurate risk estimation and the identification of key risk factors are crucial for implementing preventive measures for patients who are most at risk of this complication.**

Methods: **This prospective observational study included 113 patients over 60 years of age undergoing spinal and cranial neurosurgery between May 2023 and September 2023. The incidence of postoperative delirium was assessed using the Nursing Delirium Screening scale (Nu-DESC). Data was collected from preoperative, intraoperative, and postoperative assessments.**

Results: **The incidence of postoperative delirium was approximately 1.8%, which was insufficient to identify significant predictors of delirium. Consequently, post hoc exploratory analyses were conducted. Focusing specifically on lumbar surgery, the findings indicated that psychological factors related to pain, particularly high scores on the Pain Catastrophizing Scale, were strongly associated with postoperative pain (NRS >7). Additionally, longer surgery durations were correlated with a prolonged hospital stay, and redo surgery was a predictor of delayed first mobilization.**

Conclusions: **POD seems to be underrecognized at our institution. Raising awareness among patients and healthcare professionals about the importance of identifying and addressing this complication is essential to improve patient outcomes. Future research should focus on exploring interventions, to further enhance patient outcomes, particularly for those undergoing high-risk surgeries like intracranial procedures.**

Key words: **Postoperative delirium, incidence, spinal surgery, risk factors.**

Introduction

Delirium is defined as an acute and fluctuating disturbance in attention and awareness, often accompanied by cognitive impairments. By definition, postoperative delirium (POD) is a delirium which occurs after anesthesia and surgery before the end of the first postoperative week or discharge from hospital, whichever occurs first[1].

POD is one of the most common postoperative complications. The incidence varies according to the type of surgery[2]. Two recent meta-analyses,

The study protocol obtained permission from Liege University Hospital and Faculty Ethics Committee, Chairperson Pr V.Seutin, Internal reference number: 2023/116. Written informed consent was obtained from all participants in the study. The trial's enrollment period was from 29 May to 30 September 2023.
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performed in patients undergoing neurosurgery, reported an average incidence of POD of 20 % after intracranial neurosurgery and 11.5 % after spinal surgery[3,4]. The estimated incidence of POD after neurosurgery is, however, extremely variable, particularly for spinal procedures where it ranges from 0.84 % to 21.3 %[3]. In addition, none of the studies included in these meta-analyses were performed in Europe. It seems important to estimate the actual incidence of POD in patients undergoing neurosurgery in Europe since the incidence can vary between populations[5].

Indeed, accurate estimation of the risk together with the identification of major risk factors are the prerequisite to the implementation of preventive measures to the patients who are most likely to benefit. This seems even more relevant as POD is associated with longer hospital stays, higher readmission rates, increased healthcare costs, significant postoperative complications, cognitive deficits, and higher mortality[6,7].

The primary objective of this study is to assess the incidence of POD in patients over 60 years undergoing neurosurgery at our institution. The secondary objectives are to identify risk factors for POD primarily among preoperative, intraoperative, and postoperative data. Relationships between POD and several markers of patient's outcome such as length of hospital stay, time to first mobilization, and postoperative pain were also considered.

Methodology

Study Design and Patients

This prospective observational trial was conducted at Citadelle Hospital between May 2023 and September 2023. Our local ethics committee (Hospital and Faculty Ethics Committee of the University of Liège, Chairperson Pr V.Seutin, Ref 2023/116) approved the study. Written informed consent was obtained for all patients. Patients over 60 years of age scheduled for elective spinal or cranial neurosurgery were eligible for inclusion. However, those who were unable to understand or speak French, were hospitalized outside the neurosurgery ward, could not be assessed using the postoperative Nursing Delirium Screening Scale (Nu-DESC), or declined participation in the protocol were excluded. The manuscript adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Outcome and Measures

The primary outcome was the incidence of postoperative delirium assessed using the Nu-DESC, a five-item scale[8]. The Nu-DESC was administered by nursing staff three times daily, starting from admission to the neurosurgery ward following surgery, until hospital discharge. A Nu-DESC score ≥ 2 at any time was considered indicative of postoperative delirium. Importantly, the Nu-DESC had been routinely used in our neurosurgery ward for over one year prior to the beginning of the study. As a result, the nursing staff was already familiar with its administration and no additional formal training sessions were conducted specifically for this study.

Secondary outcome measures included the severity of postoperative pain, assessed using the Numeric Rating Scale (NRS); the length of hospital stay, defined as the number of days the patient remained hospitalized after surgery; and the time from skin closure to first mobilization.

Patient and procedure related characteristics were retrieved from the anesthetic chart and the electronic institutional medical record. In addition, several risk scores and questionnaires were administered preoperatively under the direct supervision of anesthesiologists (SS, JM) involved in the research protocol. These scores included the Mini-Cog which is a simple screening tool of cognitive impairment which includes a three-item recall and a clock drawing[9], the Alcohol Use Disorders Identification Test (AUDIT-C)[10], the Pain Catastrophizing Scale (PCS)[11], the Hospital Anxiety and Depression Scale (HAD)[12], the French Duke Activity Status Index, the Mini Nutritional Assessment Short Form (MNA SF)[13] and the Clinical Frailty Scale[14].

Statistical Analyses

All statistical analyses were performed using Stata (Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC). The distribution of quantitative variables was investigated graphically using histograms. Quantitative variables are summarized as mean±standard deviation or median [25th-75th percentiles] according to their distribution. Qualitative variables are presented as count (percentage). Crude and adjusted associations between the risk factors and binary outcome measures were assessed using univariable and multivariable binary logistic regressions. These risk factors were chosen primarily based on their perceived clinical relevance. Results are reported as odds ratio (OR) and 95% confidence interval (95% CI). The association between risk factors and time to event outcome measures such as were assessed using Cox Proportional-Hazards model. Results are reported as Hazard Ratio (HR) with 95% CI. Risk factors significantly associated with the outcome at the univariable level were included in the multivariable analyses (P value <0.05). Since no easily extractable data were available from our center due to the type of electronic medical records (DPI) used, and relevant data were readily available in the literature, we assumed a 20% incidence of POD based on findings from two recent meta-analyses[3,4], rather than relying on local data, for our sample size calculation. As a result, we estimated that including a total of 158 patients would provide 80% power to detect a 25% difference in delirium incidence between patients with and without a given risk factor at an alpha level of 0.05.

Results

Patient population

During the four-month period, a total of 183 patients were screened for recruitment. Seventy patients were excluded for variable reasons, as presented in our flowchart (Figure 1). One hundred and thirteen patients were thus retained for final analysis, including 92 patients who underwent lumbar surgery.

Primary outcome

Only two patients (1.8% of our study population) experienced at least one episode of postoperative delirium. This incidence was substantially lower than our initial estimate and, unfortunately, did not allow for the planned analysis of delirium predictors. Consequently, we redirected our focus and used the data to conduct a descriptive audit. Specifically, we examined factors associated with severe postoperative pain, prolonged hospital stay and delayed first mobilization.

Exploratory analyses

As the majority of our study population underwent lumbar surgery (92 patients, 81.4%), the statistical analysis was limited to this subgroup. Demographic and operative characteristics are presented in Table I, while preoperative scores are detailed in Table II. The mean age of our population was 70 [65-75], with 52.2 % female participants. Most patients had an ASA (American Society of Anesthesiologists) physical status of I or II (82, 89.1%). Thirty-four patients (37%) were identified as mildly or moderately frail according to the clinical frailty scale. Perioperative and postoperative data are summarized in Table III.

1. Severe postoperative pain:

Thirty-three patients (35.9%) experienced severe postoperative pain (NRS ≥7) at least once during the postoperative period. In univariable analyses, female gender (OR: 2.5 [1.0–6.2], p = 0.04), frailty (OR: 3.1 [1.3–7.9], p = 0.01), and a pain catastrophizing scale score greater than 22 (OR: 3.8 [1.5–9.4], p = 0.004) were significantly associated with severe postoperative pain. After adjusting for other risk factors, a preoperative pain catastrophizing scale score above 22 remained the sole independent predictor of severe postoperative pain (aOR: 2.9 [1.1–7.5], p = 0.03). The details of these results are presented in Table IV.

2. The length of hospital stay:

Details of the associations between perioperative risk factors and length of hospital stay are presented in Table V. Briefly, advanced age (HR: 0.97 [0.94–1.00], p = 0.03), longer surgery duration (HR: 0.94

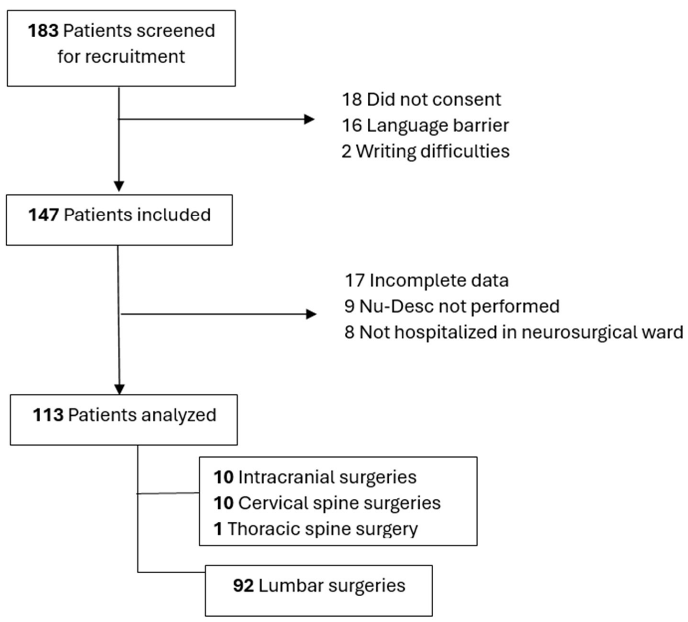

Fig. 1 — Flowchart schematizing the patient population inclusion criteria.

Table I. — Patient and procedure characteristics.

		n=92
Age, y		70 [65-75]
Female gender, n (%)		48 (52.2)
BMI, kg·m^{-2}		27.5±4.7
ASA Score		
	I	5 (5.4)
	II	77 (83.7)
	III	9 (9.8)
	IV	1 (1.1)
Active smoking		17 (18.5)
Diabetes mellitus		
	No	70 (76.1)
	Non-insulin dependent	19 (20.7)
	Insulin-dependent	3 (3.3)
Hypertension		57(62)
Previous TIA/Stroke		8 (9.1)
History of post-operative delirium		7 (7.6)
Redo surgery		29 (31.5)
Surgery duration, min		92 [64-124]
Preoperative Hb level (gr·dl^{-1})		13.9 ±1.5
Data are expressed as median[p25-p75], mean ± sd or n(%) unless otherwise stated.		

Table II. — Preoperative scores.

		n = 92
Mini-cog		
	≥ 4: Low likelihood of cognitive impairment	58 (63)
	< 4: High likelihood of cognitive impairment	34 (37)
Clinical Frailty Scale		
	1-3: very fit – managing well	58 (63)
	4-6: Very mild frailty – moderate frailty	34 (37)
Anticholinergic Drug Scale		
	0	44 (47.8)
	≥ 1	48(52.2)
Mini Nutritional Assessment		
	0-7: Malnourished	5 (5.4)
	8-11: At risk	29 (31.5)
	12-14: Normal	58 (63.0)
Pain catastrophizing scale		
	≤22: no relevant level of catastrophizing	53(58.2)
	>22: relevant level of catastrophizing	38 (41.8)
Hospital anxiety and depression scale; Anxiety		
	≤7: no anxiety	52 (56.5)
	8-10: possible anxiety	22 (23.9)
	≥11: definite anxiety	18 (19.6)
Hospital anxiety and depression scale; Depression		
	≤7: no depression	62 (67.4)
	8-10: possible depression	22 (23.9)
	≥11: definite depression	8 (8.7)
French Dukes activity status index		
	> 34: High functional capacity	29 (31.5)
	≤34: Low and moderate functional capacity	63 (68.5)
Audit-C: Alcohol Use Disorders Identification Test		
	Normal	53 (57.6)
	Misuse	37 (40.2)
	Dependency	2 (2.2)
Data are expressed as n(%) unless otherwise stated.		

Table III. — Perioperative and postoperative data.

Perioperative		n =92
Preoperative fasting for solid, h		15.3±3.0
Preoperative fasting for liquid, h		10.6±4.7
Estimated blood loss, ml		100[50-250]
Mean end-tidal CO_2		35.6±2.2
At least 1 episode of intraoperative hypotension		67(72.8)
Intraoperative EEG burst suppression		
	> 5 min	29(31.9)
	Cumulated BSR time, min	0 [0-10]
Intraoperative medications		
	Use of Parecoxib	63(68.5)
	Use of Corticoid	88 (95.3)
		n=92
NRS* for pain > 7 any time postoperatively		33(35.9)
Time to hospital discharge, day		4 [3-5]
Time to first mobilization, hour		6.4 [1.5-5.5]
Post-operative urinary retention		2(2.2)
Post-operative constipation		17(18.5)
Post-operative complications**		4(4.3)

Data are expressed as median[p25-p75], mean ± sd or n(%) unless otherwise stated.
* NRS: Numerical Rating Scale
**such as cardiovascular, pulmonary, neurological, and renal failure.

Table IV. — Predictors of severe postoperative pain (NRS > 7) (n=92).

		OR	P value	Aor	P value
Age, yr		1.0 [0.9-1.0]	0.14		
Female gender		2.5 [1.0-6.2]	**0.04**	1.8 [0.7-4.7]	0.23
Redo surgery		0.9 [0.4-2.3]	0.85		
Surgery duration, min		1.0 [1.0-1.1]	0.32		
Clinical frailty scale					
	1-3: very fit – managing well	Ref	-		
	4-6: Very mild frailty – moderate frailty	3.1[1.3-7.9]	**0.01**	2.1[0.8-5.5]	0.14
Minicog					
	< 4	1.2[0.5-2.8]	0.72		
Pain catastrophizing scale > 22; relevant level of catastrophizing		3.8 [1.5-9.4]	**0.004**	2.9[1.1-7.5]	**0.03**
Hospital anxiety and depression scale; Anxiety					
	≤7: no anxiety	Ref	-		
	8-10: possible anxiety	1.9 [0.7-5.2]	0.23		
	≥11: definite anxiety	1.4 [0.5-4.4]	0.63		
Hospital anxiety and depression scale; Depression					
	≤7: no depression	Ref	-		
	8-10: possible depression	1.2[0.4-3.3]	0.73		
	≥11: definite depression	3.5[0.8-16.1]	0.11		
Audit-C: Alcohol Use Disorders Identification Test					
	Normal	Ref	-		
	Misuse	0.8[0.3-1.9]	0.61		
	Dependency	1.7[0.1-27.9]	0.73		
Intraoperative parecoxib use		0.5[0.2-1.1]	0.09	0.6[0.2-1.6]	0.29
Spinal erector bloc		1.4[0.6-3.6]	0.43		
Surgery at more than 1 level		1.4[0.5-3.7]	0.46		

Data are expressed as median[p25-p75], mean ± sd or n(%) unless otherwise stated.

Table V. — Predictors of time to hospital discharge.

		HR	P value	aHR	P value
Age, yr		0.97 [0.94-1.0]	**0.03**	0.97 [0.94-1.00]	0.11
Female gender		1.02 [0.67-1.56]]	0.91		
Redo surgery		1.08[0.69-1.69]	0.72		
Surgery duration, per 10 min		0.94[0.90-0.99]	**0.01**	0.94 [0.89-0.99]	**0.02**
Clinical frailty score					
	1-3: very fit – managing well	Ref	-		
	4-6: Very mild frailty – moderate frailty	0.60[0.39-0.92]	**0.02**	0.69 [0.44-1.08]	0.10
Anticholinergic drug use		1.06[0.70-1.61]	0.78		
Absence of preoperative malnutrition		0.38[0.14-1.05]	0.06		
Mini-cog < 4: High likelihood of cognitive impairment		0.82[0.53-1.27]	0.38		

Data are expressed as median[p25-p75], mean ± sd or n(%) unless otherwise stated.

[0.90–0.99], p = 0.01), and frailty (HR: 0.60 [0.39–0.92], p = 0.02) were significantly associated with postoperative length of stay in univariable analysis. In the multivariable analysis, surgery duration remained the only independent predictor of length of stay. Specifically, for every additional 10 minutes of surgery, the risk of prolonged hospitalization increased, with an adjusted hazard ratio (aHR) of 0.94 [0.89–0.99], p = 0.02.

3. The time elapsed between the end of the surgery and the first mobilization:

Table VI shows the associations between risk factors and time to first mobilization. After adjustment for confounders, redo surgery remained the only significant predictor of earlier mobilization, with an adjusted hazard ratio (aHR) of 1.6 [1.00–2.78], p = 0.05.

Discussion

Key results

The incidence of POD in patients over 60 years of age undergoing neurosurgery at our institution was 1.8%. This unexpectedly low incidence did not allow us to investigate risk factors for POD, which was our main secondary objective. We therefore chose to use the data to audit several other relevant outcome measures and made the following observations. First, 35.9% of patients experienced severe postoperative pain, and the preoperative psychological aspect of pain was the main independent risk factor for its occurrence. Second, surgery duration was the most important determinant of postoperative length of hospital stay. Finally, patients with a history of prior spine surgery had significantly shorter times to first mobilization.

There are several possible explanations for the low incidence of POD observed in the present study. First and most importantly, we included a higher proportion of lumbar surgeries than expected. According to recent meta-analyses, the overall prevalence of postoperative delirium after spine surgery is 11.5%[6], whereas it reaches 20% following intracranial neurosurgery[4]. The reported incidence of POD in patients undergoing spine surgery is even lower in some studies. For example, a study conducted in the United States reported a POD incidence of 0.83%[15], and 5.1% of patients included in a Korean study experienced POD[16]. These findings are consistent with our observations. Second, we used the Nu-DESC to screen for POD in the present study. Although the Nu-DESC has high sensitivity for postoperative delirium both in the recovery room and on the surgical ward[17,18], it may have limited discriminative ability for detecting hypoactive delirium. Indeed, two of the five items in the rating scale address the hyperactive subtype. Third, although patients were screened for POD three times daily according to ESA recommendations[7], the Nu-DESC was not administered in the recovery room or intensive care unit (ICU), and no attention tests were performed. Together, this may have led to an underestimation of hypoactive POD cases and missed opportunities for early detection, especially among high-risk patients who typically receive care in these settings. In the future, attention assessments such as Months of the Year Backwards or Serial 7s could be integrated into routine practice to improve detection. However, due to practical constraints such as time limitations and staff workload in the neurosurgical environment, these tests were not systematically implemented during this study.

The low incidence of POD in our population did not allow us to search for predictors of delirium. Consequently, we decided to use the collected data to audit other important postoperative outcomes in neurosurgical patients.

We first investigated the frequency and risk factors for severe postoperative pain defined as a score of 7 or higher on a scale ranging from 0

Table VI. — Predictors of time to first mobilization (n=80).

		HR	P value	aHR	P value
Age, yr		1.02 [0.98-1.05]	0.32		
Female gender		0.94 [0.61-1.47]	0.79		
Redo surgery		1.6 [1.01-2.64]	**0.05**	1.67[1.00-2.78]	**0.05**
Surgery duration, per 10 min		0.97 [0.92-1.01]	0.16	0.99[0.94-1.27]	0.08
Clinical frailty score					
	1-3: very fit – managing well	ref			
	4-6: Very mild frailty – moderate frailty	0.97[0.61-1.54]	0.90		
Preoperative malnutrition		0.88[0.36-2.20]	0.79		
Preoperative hypertension		1.48 [0.93-2.34]	0.09	1.43[0.88-2.3]	0.15
Pain Catastrophizing Scale > 22; relevant level of catastrophizing		1.12[0.71-1.77]	0.62		
Hospital anxiety and depression scale; Anxiety ≥ 11		0.77[0.43-1.35]	0.36		
Preoperative fasting duration for liquid, h		1.06[0.91-1.24]	0.46		
Cumulated blood loss, per 100 ml		0.96[0.86-1.08]	0.53		
Cumulated crystalloid infusion, per 250 ml		0.78[0.62-0.99]	0.04	0.79[0.61-1.03]	0.08
End of surgery after 2PM		0.68[0.42-1.09]	0.11	0.77[0.46-0.1.27]	0.30
At least one episode of postoperative NRS* for pain >7		0.87[0.55-1.39]	0.57		

Data are expressed as median[p25-p75], mean ± sd or n(%) unless otherwise stated.
* NRS: Numerical Rating Scale.

to 10. Female gender, high levels of frailty and a preoperative pain catastrophizing were all significantly associated with severe postoperative pain. These results are consistent with previous studies that had already identified frailty[19,20] and higher levels of catastrophizing pain[21] as risk factors for post-operative pain.

Postoperative length of stay (LOS) is a key indicator of recovery and a major driver of healthcare costs, especially after spinal surgery[22]. Identifying factors that influence LOS is crucial for improving patient care and reducing costs. Our results indicate that advanced age, longer surgery duration, and higher levels of frailty were significantly associated with prolonged postoperative stays. These findings are consistent with previous research, particularly regarding the impact of frailty[23].

Finally, we examined predictors of time to first postoperative mobilization, a critical component of enhanced recovery protocols linked to fewer complications, faster functional recovery, and shorter hospital stays[24]. Interestingly, our multivariable analysis revealed that patients undergoing redo surgeries mobilized earlier, despite the greater complexity typically associated with such procedures. This may reflect increased patient awareness and motivation stemming from prior surgical experience.

Limitations

This study has several important limitations. Most notably, the number of events observed for the primary outcome was significantly lower than anticipated, preventing us from adequately addressing our original research question. As a result, we conducted a series of unplanned exploratory analyses. These analyses should be interpreted with caution, as they carry only exploratory value. Our ability to draw robust conclusions is further limited by additional methodological shortcomings. First, we were unable to recruit the number of patients initially planned and had to exclude some participants due to missing data. We had assumed that missing data would be minimal and designed a 4-month recruitment period, which could not be extended due to logistical constraints. These factors contributed to a loss of statistical power and may have introduced recruitment bias. Second, the number of variables tested in our exploratory analyses was relatively high in comparison to the sample size. This raises the risk of overfitting and Type I error, especially given that no formal corrections for multiple comparisons were applied. The exclusion of patients who did not undergo Nu-DESC assessments, as well as those who were not admitted to the neurosurgery ward is another source of bias. In addition, as mentioned above, the use of Nu-DESC alone without an attention test may have contributed to an underestimation of POD. Finally, although the nursing staff was familiar with the Nu-DESC, we acknowledge that the absence of structured refresher training or formal standardization process may have introduced variability in assessments, which represents a limitation of the study.

Clinical implications

First, the incidence of postoperative delirium appears to be low following spinal neurosurgery. It may therefore be more appropriate to focus research and clinical efforts on populations at higher risk, such as patients undergoing intracranial neurosurgery. Second, the incidence of severe postoperative pain after spinal procedures is substantial. Patients with risk factors such as frailty or pain catastrophizing warrant a tailored approach and intensive postoperative monitoring to manage severe pain effectively. Finally, while patients with a history of prior spinal surgery tend to mobilize earlier and may recover more quickly, the association between longer surgery duration and prolonged length of stay underscores the impact of the extent of surgery on postoperative recovery.

Conclusion

Postoperative delirium was observed in approximately 2% of neurosurgical patients at our institution. Increasing awareness among both patients and healthcare professionals about the importance of recognizing this complication is essential. Our findings also highlight the significance of other clinical outcomes, such as severe postoperative pain, in neurosurgical patients. Additionally, they underscore the role of surgery duration and preoperative pain catastrophizing as important contributors to postoperative outcomes..

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