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Neurological Recovery After Surgery for Traumatic Spinal Cord Injury: Associated Factors in an Ivorian Cohort

Running title: Neurological recovery after surgery for SCI (43 characters)

TETI Faozo Stéphane Landry[1,2], DONGO Koffi Yves Soress[1,2], FIONKO Yao Bernard[1,2], YAO Konan Serges[1,2], KEKE Kouadio Jean-Baptiste[1,2], HAIDARA Aderehime[1,2].

[1]Department of Neurosurgery, Bouaké University Hospital, Bouaké, Côte d'Ivoire

[2] Faculty of Medical Sciences (UFR des Sciences Médicales), Alassane Ouattara University, Bouaké, Côte d'Ivoire

Corresponding author

TETI Faozo Stéphane Landry, Department of Neurosurgery, Bouaké University Hospital, 01 BP 1174 Bouaké 01, Côte d'Ivoire.

Telephone: +225 07 49 44 47 77 – ORCID: 0009-0007-8602-9881

ORCID

Teti 0009-0007-8602-9881; Dongo 0009-0009-4047-6891; Fionko 0009-0005-5593-7647; Yao 0009-0004-6417-4066; Keke 0000-0002-0860-8606; Haidara 0009-0001-0412-9982

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Abstract

Objective. To identify factors independently associated with neurological recovery, measured as ASIA grade improvement, after surgery for traumatic spinal cord injury (SCI) at an Ivorian referral centre.

Methods. Single-centre cohort (Bouaké University Hospital; retrospective phase 2017–2021, prospective phase January 2025–June 2026), reported according to STROBE. Of 345 operated patients, we analysed the 248 survivors with an initial deficit (ASIA A–D). The primary outcome was recovery, defined as an improvement of at least one ASIA grade between admission and the last documented assessment (median follow-up 45 days). Predictors were admission ASIA grade (complete vs incomplete injury), lesion level, AOSpine classification, time to surgery (counted from hospital admission) and age. We fitted a multivariable logistic regression model and assessed apparent discrimination (AUC) and calibration (Hosmer-Lemeshow test). Exploratory analyses tested alternative codings of surgical delay.

Vol.10, No.05; 2026

ISSN: 2581-3366

Results. Median age was 35 years [IQR 25–48]; 80.9% were men. A complete injury (ASIA A) was present in 41.7% and median time to surgery was 3 days [2–4]. Recovery occurred in 111 of 248 survivors with a deficit (44.8%), with a gradient by initial severity (ASIA A 30.9%; B 45.8%; C 56.6%; D 56.6%). In multivariable analysis (n = 247; 110 events), only incomplete injury (ASIA B–D vs A) was associated with recovery (adjusted OR 2.50; 95% CI 1.41–4.43; p = 0.002): 53.2% of incomplete injuries recovered versus 30.9% of complete injuries. We detected no association with time to surgery ≤ 3 days (adjusted OR 0.70; 95% CI 0.39–1.27), AOSpine type, lesion level or age. Apparent discrimination was modest (AUC 0.65), with no major calibration defect (Hosmer-Lemeshow p = 0.98). Alternative codings of delay (continuous, log-transformed, 24- and 48-hour thresholds, quartiles) did not change these findings.

Conclusion. In this West African surgical cohort, neurological recovery depended on initial severity. We detected no independent association with surgical timing or injury morphology, but estimates are imprecise and an important effect of timing cannot be excluded. The modest discrimination suggests unmeasured factors (MRI contusion extent, rehabilitation, secondary complications); prospective studies should test them.

Keywords: *traumatic spinal cord injury; ASIA; neurological recovery; AOSpine; surgical timing; Côte d'Ivoire; global neurosurgery.*

What was already known

- The ASIA grade at admission is the main prognostic factor in traumatic spinal cord injury (SCI).
- In high-income countries, decompression within 24 hours is associated with better recovery (“time is spine”).
- In francophone West Africa, where early surgery remains hard to access, the factors of recovery after surgery are poorly known.

What this study adds

- 345 operated SCI patients in an Ivorian referral centre; 248 survivors with an initial deficit (ASIA A–D), evaluable for recovery.
- Neurological recovery (gain ≥ 1 ASIA grade) in 44.8% of them: 30.9% if ASIA A, 56.6% if ASIA D.
- Only independent factor: an incomplete injury (ASIA B–D; adjusted OR 2.50; 95% CI 1.41–4.43).
- No association detected with time to surgery (counted from admission), AOSpine type, lesion level or age. Confidence intervals are wide (delay ≤ 3 d: adjusted OR 0.70; 95% CI 0.39–1.27): a large effect is not excluded.
- The result on time to surgery does not change with its coding, but our analyses correct neither confounding by indication nor survival bias.

Vol.10, No.05; 2026

ISSN: 2581-3366

1. Introduction

Traumatic spinal cord injury (SCI) is one of the leading causes of permanent neurological disability in young adults worldwide [1]. Neurological recovery varies widely between patients and remains difficult to predict. The burden is heavier in low- and middle-income countries, where road traffic crashes predominate [2,3]. In sub-Saharan Africa, published series mostly describe men, often severely injured and managed late [4, 5].

Beyond survival, the challenge in SCI is recovery. The best-established prognostic factor is severity at admission, measured with the American Spinal Injury Association Impairment Scale (ASIA) according to the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI): incomplete injuries recover far more often than complete ones [6]. The role of surgery, and above all of its timing, is much debated. The STASCIS study [7], a pooled analysis of individual patient data [8], a clinical practice guideline [9] and a meta-analysis [10] suggest that decompression within 24 hours improves the chances of recovery. This is the “time is spine” formula, supported by preclinical data [11]. The AOSpine classification, for its part, describes injury morphology and guides surgical strategy [12,13].

Almost all of these data come from high-income health systems, where ultra-early decompression is feasible. In a West African referral centre, the care pathway extends delays well beyond 24 hours: patients are often referred, transport is rarely medicalised, and imaging and the operating theatre are reached late. Once surgery has been performed, which factors remain associated with recovery? Little is known. A related manuscript from the same cohort (see Declarations) showed that initial severity (ASIA A) was the main factor associated with in-hospital mortality. This work extends it to the functional side. We hypothesised that initial severity, rather than surgical timing or injury morphology, would remain the main factor associated with recovery. We therefore sought the factors independently associated with neurological recovery after surgery, in a setting where ultra-early decompression remains rare.

2. Patients and Methods

2.1 Study design, setting and period

This is a secondary analysis of a single-centre cohort from the Neurosurgery Department of Bouaké University Hospital (Côte d'Ivoire), reported according to the STROBE recommendations [14]. The retrospective phase covers patients hospitalised from 1 January 2017 to 31 December 2021; the prospective phase covers the period from 1 January 2025 to 30 June 2026. The years 2022 to 2024 are not in the audited database available to us. Of 383 records identified, 17 were excluded (9 non-traumatic conditions, 5 duplicates, 3 inconclusive records): 366 patients were included. The registers do not allow these 366 patients to be allocated exactly between the two phases. The selection of the analysis population is detailed in Figure 1.

Vol.10, No.05; 2026

ISSN: 2581-3366

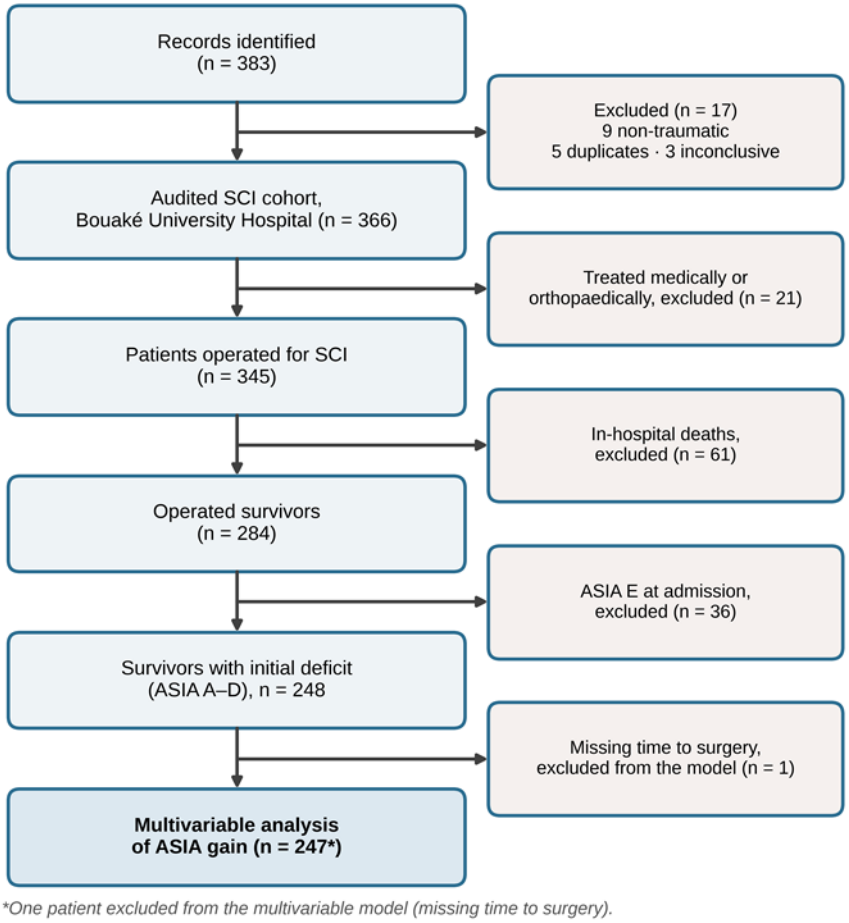


Figure 1. Flow diagram of the selection of the analysis population (STROBE).

2.2 Population

Among the 366 patients, we retained those hospitalised for a traumatic SCI confirmed clinically and on imaging, and operated. Patients treated medically or orthopaedically (n = 21) were excluded. Among the 345 operated patients, the analysis of recovery was restricted to survivors (61 in-hospital deaths excluded, recovery not being assessable) with an initial deficit, i.e. ASIA grade A to D (36 ASIA E patients excluded: no deficit to improve). The analysis population therefore comprises 248 patients; one patient was dropped from the multivariable model for lack of a surgical delay (n = 247).

2.3 Variables and definitions

We graded the deficit on the ASIA scale, in accordance with the ISNCSCI [6]. Bony injuries were classified according to the AOSpine system [12,13] and grouped into three types: A (compression), B (distraction) and C (translation). The primary outcome was neurological recovery: a gain of at least one ASIA grade between admission and the last documented clinical

Vol.10, No.05; 2026

ISSN: 2581-3366

assessment. This assessment took place at a date that varied between patients (median 45 days [14–180]) and was not standardised. For their clinical relevance, we retained the following predictors: admission ASIA grade (complete [A] or incomplete [B–D] injury; as an ordinal variable in exploratory analysis); lesion level (cervical, thoracic, lumbosacral); AOSpine type (A, B, C); time to surgery; age (per 10 years). Time to surgery is counted from admission to the hospital, not from injury. We dichotomised it at the median (≤ 3 days versus > 3 days). This category does not correspond to the "early" surgery of the literature, defined at 24 hours.

2.4 Ethical considerations

The study complies with the principles of the Declaration of Helsinki. No institutional ethics committee existed in the establishment during the study period. The Neurosurgery Department approved the protocol internally, with the authorisation of the hospital management. Records of the retrospective phase were used after anonymisation, with waiver of consent. In the prospective phase, patients or their legal representatives gave informed consent.

2.5 Statistical analysis

The database was audited: re-entry of follow-up ASIA grades from the source records, reconciliation of operative status, internal consistency checks. We analysed complete cases, missing data being few and apparently unrelated to outcome. Categorical variables are given as counts and percentages, quantitative variables as median [interquartile range]. To compare recovered and non-recovered patients, we used the χ^2 test, Fisher's exact test or the Mann-Whitney test depending on the variable. As the outcome is binary (recovery yes or no), we chose logistic regression. A survival approach was not feasible: follow-up dates are heterogeneous and unreliable. Time to surgery was dichotomised at the median (≤ 3 days; 71.3% of operated patients, because many patients were operated on exactly day 3). Other codings were explored in complementary analyses. The multivariable model includes all the selected predictors, i.e. more than ten events per estimated parameter. We assessed discrimination by the area under the ROC curve (apparent AUC, not corrected for optimism) and calibration by the Hosmer-Lemeshow test, whose non-significance is not enough to prove good calibration. Odds ratios (OR) are given with their 95% confidence interval. The significance threshold was 0.05. Analyses were performed in Python 3.12 (pandas, statsmodels, scikit-learn).

We conducted these complementary analyses after obtaining the main result, without a dated prior protocol. They do not modify the main model. The admission ASIA grade was treated as an ordinal variable. Time to surgery was recoded in several ways: continuous variable (per day), logarithmic transformation (skewed distribution), 24-hour (≤ 1 day) and 48-hour (≤ 2 days) thresholds, quartiles. To look for a non-linear relationship, we compared a natural cubic spline (3 degrees of freedom) with the linear term by a likelihood-ratio test. The results are grouped in Table 5 and do not constitute confirmation.

Vol.10, No.05; 2026

ISSN: 2581-3366

3. Results

Among the variables studied, only initial neurological severity remained associated with recovery. This result does not change with the other codings of time to surgery tested in the exploratory analyses.

3.1 Characteristics of the operated cohort

We analysed 345 patients operated on for SCI. Median age was 35 years [IQR 25–48], and men predominated (80.9%; sex ratio 4.2). Road traffic crashes were the leading mechanism (62.9%). Among the patients, 61.7% had been referred from another facility. A complete injury (ASIA A) affected 41.7% of operated patients, a cervical injury 49.0%. Decompression was performed in 309 patients (89.6%), arthrodesis in 281 (81.4%); 36 patients (10.4%) had posterior arthrodesis alone. Median time to surgery, counted from admission, was 3 days [2–4]; 71.3% of patients were operated within 3 days (Table 1).

Table 1. Characteristics of the operated cohort (n = 345).

Parameter	**n (%) / median [IQR]**
Age (years), median [IQR]	35 [25–48]
Male sex	279 (80.9%)
Health insurance	52 (15.1%)
Referred patient	213 (61.7%)
Mechanism	
Road traffic crash	217 (62.9%)
Fall	90 (26.1%)
Assault	18 (5.2%)
Other	20 (5.8%)
Spinal segment	
Cervical	169 (49.0%)
Thoracic	123 (35.7%)
Lumbar	43 (12.5%)
Sacral	10 (2.9%)
ASIA grade at admission	
A (complete)	144 (41.7%)
B	49 (14.2%)
C	57 (16.5%)

Vol.10, No.05; 2026

ISSN: 2581-3366

Parameter	n (%) / median [IQR]
D	56 (16.2%)
E	39 (11.3%)
AOSpine type	
A (compression)	109 (31.6%)
B (distraction)	80 (23.2%)
C (translation)	156 (45.2%)
Surgical management	
Decompression + arthrodesis	164 (47.5%)
Laminectomy + arthrodesis	81 (23.5%)
Decompression alone	64 (18.6%)
Posterior arthrodesis	36 (10.4%)
Any decompression (first three lines)	309 (89.6%)
Time to surgery from admission (d), median [IQR]	3 [2–4]
Time to surgery ≤ 3 days	246 (71.3%)
Follow-up time (d), median [IQR]	45 [14–180]

3.2 Overall neurological outcome

Among the 345 operated patients, neurological outcome, defined on the ASIA grade, was distributed as follows: improvement in 111 patients (32.2%), stability in 168 (48.7%), deterioration in 5 (1.4%), in-hospital death in 61 (17.7%). Among the 284 survivors, 81 (28.5%) were walking, alone or with assistance, at the last assessment. The analysis of recovery covers the 248 survivors with an initial deficit (ASIA A–D). In this group, 111 patients (44.8%) gained at least one ASIA grade and 5 (2.0%) deteriorated. The recovery rate increased with the admission grade: 30.9% for ASIA A, 45.8% for ASIA B, 56.6% for each of grades C and D (Figures 2 and 3; Table 2).

Vol.10, No.05; 2026

ISSN: 2581-3366

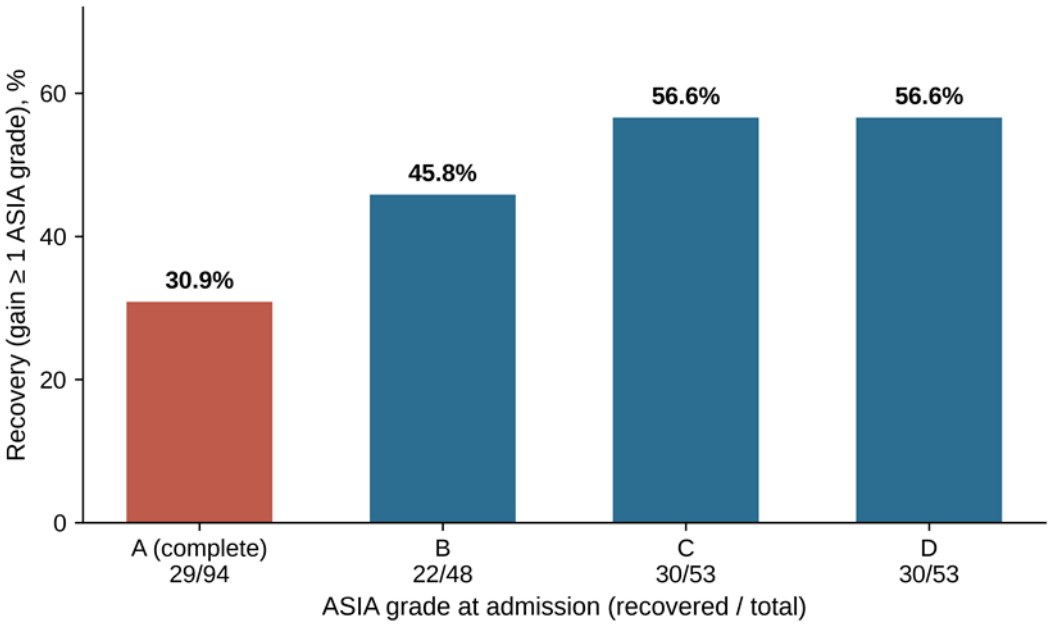


Figure 2. Neurological recovery rate (gain ≥ 1 ASIA grade) by ASIA grade at admission, in operated survivors with an initial deficit (n = 248).

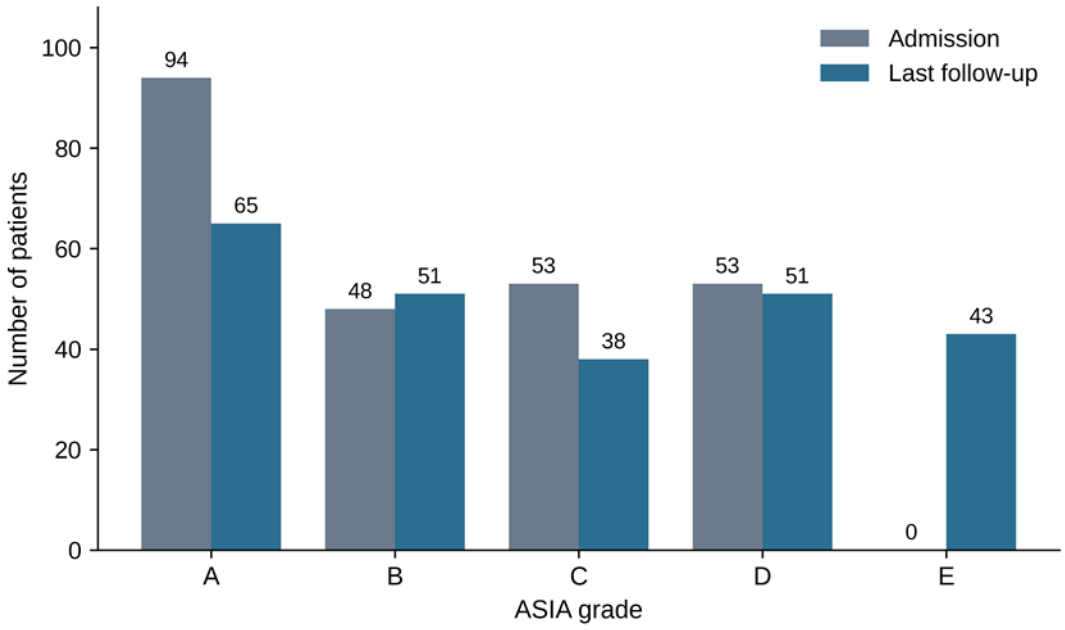


Figure 3. Distribution of ASIA grades at admission and at last follow-up (operated survivors with an initial deficit).

Vol.10, No.05; 2026

ISSN: 2581-3366

Table 2. Neurological recovery by ASIA grade at admission (survivors with a deficit, n = 248).

ASIA at admission	n	Recovered, n (%)
A (complete)	94	29 (30.9%)
B	48	22 (45.8%)
C	53	30 (56.6%)
D	53	30 (56.6%)
Total	**248**	**111 (44.8%)**

3.3 Bivariate analysis

In bivariate analysis, only complete injury (ASIA A) distinguished recovered from non-recovered patients: 26.1% of recovered patients had a complete injury, versus 47.4% of non-recovered patients ($p < 0.001$). Age, cervical level, AOSpine type C, sex and time to surgery were not associated with recovery (Table 3).

Table 3. Comparison of recovered and non-recovered patients (bivariate analysis).

Variable	Recovered (n = 111)	Not recovered (n = 137)	p
Age (years), median [IQR]	34 [23–50]	37 [27–49]	0.354
Complete injury (ASIA A), n (%)	29 (26.1)	65 (47.4)	**<0.001**
Cervical level, n (%)	58 (52.3)	61 (44.5)	0.279
AOSpine type C, n (%)	48 (43.2)	63 (46.0)	0.762
Male sex, n (%)	94 (84.7)	109 (79.6)	0.381
Time to surgery from admission (d), median [IQR]	3 [2–4]	2 [2–4]	0.260

3.4 Multivariable analysis

In the multivariable model (n = 247; 110 events), incomplete injury (ASIA B–D vs A) was the only factor independently associated with recovery, with an adjusted OR of 2.50 (95% CI 1.41–4.43; $p = 0.002$). In absolute terms, 53.2% of patients with an incomplete injury (82/154) recovered, versus 30.9% (29/94) of patients with a complete injury. Time to surgery (≤ 3 d: adjusted OR 0.70; 95% CI 0.39–1.27), AOSpine type, lesion level and age were not associated with ASIA gain in this model. Their confidence intervals are wide and do not exclude important effects. Discrimination was modest (apparent AUC 0.65); the Hosmer-Lemeshow test showed no major calibration defect ($p = 0.98$) (Table 4; Figure 4).

Vol.10, No.05; 2026

ISSN: 2581-3366

Table 4. Factors associated with neurological recovery (logistic regression).

Variable	Crude OR	95% CI	Adjusted OR	95% CI (p)
Incomplete injury (ASIA B–D)	2.52	1.47–4.33	**2.50**	**1.41–4.43 (0.002)**
AOSpine type B (vs A)	0.71	0.36–1.41	0.83	0.41–1.70 (0.609)
AOSpine type C (vs A)	0.78	0.43–1.41	1.03	0.55–1.93 (0.932)
Thoracic level (vs cervical)	0.85	0.49–1.49	0.98	0.54–1.75 (0.938)
Lumbosacral level (vs cervical)	0.49	0.23–1.03	0.55	0.25–1.19 (0.129)
Time to surgery ≤ 3 d (vs > 3 d)	0.68	0.39–1.21	0.70	0.39–1.27 (0.239)
Age (per 10 years)	0.92	0.79–1.09	0.97	0.81–1.15 (0.701)

n = 247; events = 110; apparent AUC = 0.65; Hosmer-Lemeshow p = 0.98. OR: odds ratio; 95% CI: 95% confidence interval; ASIA: American Spinal Injury Association Impairment Scale; AOSpine: AO Spine classification.

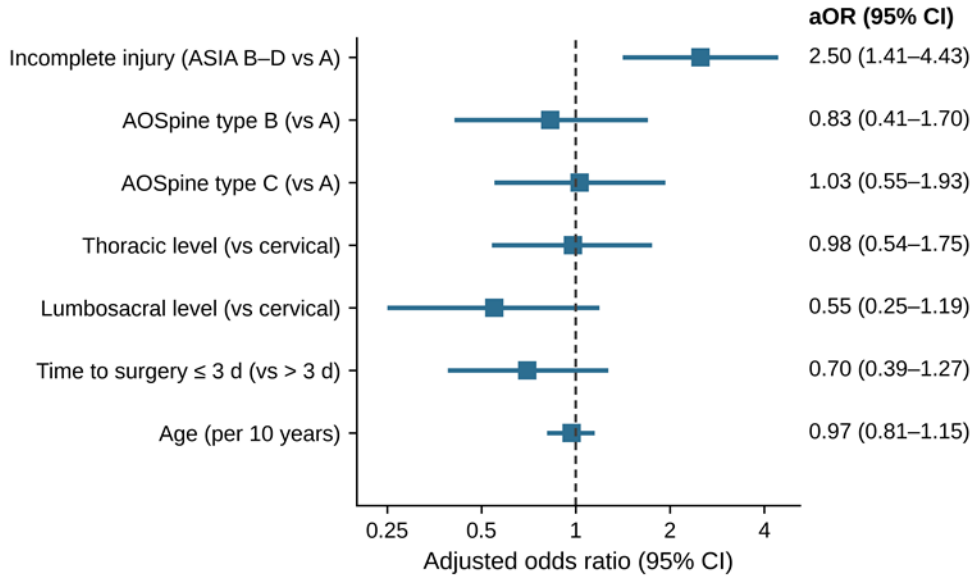


Figure 4. Adjusted odds ratios of the factors associated with neurological recovery (forest plot). The dotted vertical line corresponds to OR = 1.

Vol.10, No.05; 2026

ISSN: 2581-3366

3.5 Exploratory complementary analyses

With the admission ASIA grade as an ordinal variable (from most to least severe), each additional grade increased the odds of recovery (adjusted OR per grade 1.44; 95% CI 1.14–1.82; p = 0.002). The other variables remained non-significant. This result is compatible with a graded effect of initial severity.

Coding of time to surgery. Whatever the coding, we detected no association between time to surgery and recovery (Table 5). As a continuous variable, each additional day was not associated with recovery (adjusted OR 1.05; 95% CI 0.96–1.15; p = 0.273); the same applied after logarithmic transformation (p = 0.469). At the 24-hour threshold (≤ 1 day), 28 of the 247 patients (11.3%) had been operated on: the association was not significant (adjusted OR 0.76; 95% CI 0.32–1.82; p = 0.536), and the wide interval reflects this small number. At the 48-hour threshold (≤ 2 days), p = 0.334. The quartiles showed no monotonic trend (all p ≥ 0.39). We found no non-linear relationship (natural cubic spline versus linear term: $\chi^2 = 0.35$; p = 0.554). The estimates remain imprecise. Their direction (continuous OR above 1) suggests confounding by indication or by survival rather than a deleterious effect of speed. The adjusted OR for incomplete injury varied little across these codings (2.33 to 2.50).

Summary. These exploratory analyses, conducted after the main result, show that the absence of association for time to surgery does not depend on the coding chosen. They correct neither confounding by indication nor survival bias (see Limitations): they do not prove the absence of an effect.

Vol.10, No.05; 2026

ISSN: 2581-3366

Table 5. Exploratory complementary analyses: coding of time to surgery and of initial severity.

Analysis	Adjusted OR, incomplete injury (95% CI)	n / events	Effect of time to surgery — aOR (95% CI), p
Main model (time to surgery ≤ 3 d)	**2.50 (1.41–4.43)**	247 / 110	0.70 (0.39–1.27), p = 0.239
Continuous time to surgery (per day)	2.49 (1.40–4.42)	247 / 110	1.05 (0.96–1.15), p = 0.273
Log-transformed time to surgery	2.47 (1.39–4.38)	247 / 110	1.18 (0.75–1.85), p = 0.469
24-h threshold (≤ 1 d)	2.44 (1.37–4.35)	247 / 110	0.76 (0.32–1.82), p = 0.536
48-h threshold (≤ 2 d)	2.41 (1.35–4.28)	247 / 110	0.77 (0.46–1.30), p = 0.334
Time to surgery in quartiles	2.33 (1.30–4.19)	247 / 110	all NS (p ≥ 0.39)
Ordinal ASIA (per grade)	1.44 (1.14–1.82), p = 0.002 †	247 / 110	—
Exploratory analyses, without a dated prior protocol; they do not modify the main estimate of the model.			

Each row corresponds to the main model in which only the specification indicated was modified; the other covariates (AOSpine, level, age) are retained. Test for non-linearity of time to surgery (spline vs linear): p = 0.554. † OR per additional ASIA grade (ordinal variable, effect of severity rather than of a binary incomplete injury). Effect of time to surgery not reported for the ordinal ASIA model. NS: not significant.

4. Discussion

Only initial neurological severity remains associated with recovery, and this association varies little with the coding of time to surgery in our exploratory analyses. Nearly one survivor in two (44.8%) gained at least one ASIA grade. We detected no independent association for time to surgery, AOSpine type, lesion level or age, but the confidence intervals do not allow large effects to be excluded. These results are consistent with our hypothesis. They extend, on the functional side, what we observed for mortality, where complete injury (ASIA A) was the main factor associated with death.

Initial severity and recovery gradient. Recovery rises from 30.9% for ASIA A to 56.6% for ASIA D. This gradient is consistent with the pathophysiology and with the literature. A complete injury reflects a severe anatomical and functional interruption, whose potential for recovery, spontaneous or after surgery, is limited. Preserved sub-lesional function (grades B to D) bears

Vol.10, No.05; 2026

ISSN: 2581-3366

witness to recoverable neural tissue [1,6]. The admission ASIA grade is one of the most robust and most often reproduced prognostic factors in spinal cord trauma. In absolute terms, 53.2% of incomplete injuries recovered, versus 30.9% of complete injuries: the gap is more modest than the odds ratio of 2.50 suggests. The rates are also not strictly comparable from one grade to another. Grade D can only progress to E, and the minimal gain from grade A (to B) does not always reflect true spinal cord recovery.

No association detected between surgical timing and recovery. This result calls for caution. Time to surgery is counted from admission, not from injury. Yet the "time is spine" concept [8–10] rests on the delay from injury, which our cohort does not allow us to assess: 61.7% of operated patients were referred. The estimates are imprecise: the confidence interval of the adjusted OR (0.39–1.27) is compatible with a reduction of more than 60% as well as with an increase of more than a quarter in the odds of recovery. The direction of the coefficients (continuous OR of 1.05 per day; longer median delay among recovered patients) suggests confounding by indication or survival bias, rather than a benefit of waiting. High-income studies place the critical window within the first 24 hours. In our care pathway, the median delay is 3 days and only 28 of the 247 evaluable patients (11.3%) were operated on within 24 hours of admission: power is limited. Restriction to survivors poses another problem, because it conditions the analysis on an event occurring after the exposure. If early surgery reduces mortality, the survivors of the early group include more severely injured patients, which pulls the association downward. In East Africa, a longer admission delay was moreover accompanied by lower mortality [15]. All patients in this analysis were operated on: we cannot compare surgery with abstention. These elements do not call into question the value of early surgery. They are a reminder that pre-hospital and hospital delays must be shortened to reach the useful window.

AOSpine morphology and lesion level. The AOSpine classification describes bony morphology and instability, and guides fixation. It predicts functional neurological impairment poorly, which the ASIA grade captures better [12,13]: the absence of an independent association with recovery is therefore unsurprising. Lesion level is not predictive either. The unfavourable trend of lumbosacral lesions (adjusted OR 0.55) is not significant, perhaps for lack of numbers.

Unmeasured factors. An apparent AUC of 0.65 is a finding in itself: initial severity explains only part of the course. Other factors, absent from our database, may matter: extent of spinal cord contusion and oedema on MRI, timing and intensity of rehabilitation, nutritional status, secondary complications (respiratory, cutaneous, urinary, thromboembolic), quality of nursing. We did not test this hypothesis. Prospective studies will first need to document rehabilitation and complications before making them priority targets. Measurement noise in the outcome may also play a part: ASIA grades recorded without standardisation, variable follow-up duration.

Exploratory analyses. The association between initial severity and recovery varies little across the specifications tested: the OR for incomplete injury ranges from 2.33 to 2.50, and time to surgery remains unassociated with recovery whatever its coding, with no detectable non-linear

Vol.10, No.05; 2026

ISSN: 2581-3366

relationship (Table 5). Conducted after the main result and without a dated prior protocol, these analyses are exploratory. They show that the answer does not depend on a coding choice, not that it is free of bias.

Comparison with African series. The African surgical and hospital series [16–18] differ in population, recovery criterion and duration of assessment. Direct comparison of rates is therefore delicate. Other resource-limited settings have described neglected injuries seen late [19]. In the Tanzanian registry, neurological improvement was reported in only 13% (47/370) of patients of AIS grade A to D in complete cases [20], versus 44.8% in our cohort. This gap may reflect the proportion of patients operated on (54% versus 100%), the median delay to care (13 days) and the definitions used; it should be read with caution. The Ethiopian cohort of Mengesha et al. [21], dominated by falls (45.2%), associated late presentation with a 30-day mortality of 22.2%.
Implications for practice and public health. Our results do not directly test these levers, but they point the way for action. Systematically assess the ASIA grade at admission: it is a prognostic marker and a tool for dialogue with families. Shorten delays, through early referral and medicalised transport, so that more patients reach the operating theatre within the useful window. Invest in early rehabilitation and the prevention of complications: these avenues are plausible, their effect remains to be demonstrated, and they are more accessible in the short term than expanding surgical capacity. In global neurosurgery, the functional prognosis of SCI will depend not only on the expertise of referral centres but on the strength of the whole chain of care [22,23].

4.1 Strengths

This study draws on a surgical cohort of good size, an audited database, standardised classifications (ASIA, AOSpine), predictors chosen on clinical grounds, and an assessment of discrimination and calibration. Restriction to survivors with an initial deficit removes the ceiling effect (ASIA E) and non-evaluable patients, but introduces a selection bias (see Limitations). Recoding time to surgery in several exploratory analyses shows that the absence of a detected association does not depend on the coding.

4.2 Limitations

The single-centre design and recruitment in a referral centre expose the study to selection and referral biases. Partly retrospective data collection exposes it to missing data, residual confounding and heterogeneous follow-up times (median 45 days), which may lead to underestimation of late recovery. Several important factors (MRI contusion, intensity of rehabilitation, length of stay, detailed complications) were not usable. The low variability of delays limits the ability to detect an effect of earliness. Five limitations weigh on the interpretation. (i) Time to surgery is counted from admission, not from injury: the “time is spine” concept cannot be tested. (ii) The analysis is restricted to survivors, and therefore conditioned on an event occurring after the exposure; we did not perform an analysis with a composite outcome (death counted as no recovery). (iii) The outcome rests on the last documented assessment, at a

Vol.10, No.05; 2026

ISSN: 2581-3366

variable date (median 45 days [14–180]), without adjustment for follow-up duration; the delay between injury and the initial ASIA examination is not standardised. (iv) The AUC is apparent, without confidence interval or internal validation. (v) MRI, rehabilitation and detailed complications were not tested. The exploratory analyses on the coding of time to surgery do not replace independent external validation. A tertiary centre that receives patients from several regions makes the results probably transferable to West African specialised centres subject to the same constraints, but extrapolation to other health systems remains cautious. These results are associations observed in a surgical cohort, not causal relationships. This cohort is shared with other manuscripts (see Declarations).

4.3 Perspectives

MRI and rehabilitation indicators will need to be systematically integrated, patients followed for longer with standardised outcomes (walking, bladder and sphincter function, quality of life, return to work), and the results validated in several centres. A multicentre West African prospective registry would make it possible to clarify the modifiable factors and to assess the effect of shorter delays and strengthened rehabilitation. At the individual level, we will also need to perform an analysis with a composite outcome (death counted as no recovery), adjusted for follow-up duration.

5. Key messages

Take-home points

- The initial ASIA grade is the most informative variable among those analysed for estimating recovery after SCI surgery, but its discriminating power remains modest.
- Among 248 operated survivors with an initial deficit, 44.8% gained at least one ASIA grade.
- Only incomplete injury (ASIA B–D) was independently associated with recovery (adjusted OR 2.50; 95% CI 1.41–4.43).
- We detected no independent association for time to surgery (counted from admission), AOSpine type, lesion level or age; the confidence intervals are wide.
- A modest apparent AUC (0.65) is compatible with a role for unmeasured factors (MRI, rehabilitation, complications), a hypothesis to be tested.
- The result on time to surgery does not depend on the coding in the exploratory analyses, but these correct neither confounding by indication nor survival bias.
- Shortening delays and strengthening rehabilitation remain plausible avenues, not tested here.

6. Conclusion

In this Ivorian surgical cohort, neurological recovery after surgery for SCI depended mainly on initial severity: 53.2% of incomplete injuries recovered, versus 30.9% of complete injuries

Vol.10, No.05; 2026

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(adjusted OR 2.50). We detected no independent association for time to surgery, injury morphology or age. The precision of the estimates does not allow important effects to be excluded, especially for time to surgery. The modest discrimination of the model suggests that neurological outcome also depends on factors we did not measure: rehabilitation, prevention of complications, care pathway. Multicentre prospective studies will need to test their role, and to measure the delay from injury.

7. Declarations

Conflicts of interest. The authors declare no conflicts of interest related to this work.
Funding. This work received no specific funding.

Ethics approval. Bouaké University Hospital did not have a constituted ethics committee during the study period; the study was conducted after authorisation from the head of the neurosurgery department and the hospital management, in accordance with the principles of the Declaration of Helsinki. It has since received the approval of the Institutional Ethics Committee of Bouaké University Hospital (approval no. CEI/CHU-BKE/138/2026).

Related manuscripts. This analysis relies on the same single-centre cohort of 366 patients as other manuscripts from the department (mortality and recovery in SCI; AOSpine classification; complete ASIA A injuries; surgical delay; return to walking). It concerns the same patients and the same event as the secondary outcome of the prognostic manuscript. It differs from it in its population (operated patients only: 248 survivors with an initial deficit), its dichotomy of severity (complete or incomplete injury) and its covariates (surgical delay, AOSpine type). Its results are therefore not independent of those of these manuscripts. A copy of the related manuscripts is attached to the submission.

Data availability. Anonymised data are available from the corresponding author on reasonable request, subject to institutional and ethical authorisations.

8. References

Ahuja CS, Wilson JR, Nori S, Kotter MRN, Druschel C, Curt A, Fehlings MG. Traumatic spinal cord injury. Nat Rev Dis Primers. 2017;3:17018. https://doi.org/10.1038/nrdp.2017.18

Guan B, Anderson DB, Chen L, Feng S, Zhou H. Global, regional and national burden of traumatic brain injury and spinal cord injury, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. BMJ Open. 2023;13(10):e075049. https://doi.org/10.1136/bmjopen-2023-075049

Singh A, Tetreault L, Kalsi-Ryan S, Nouri A, Fehlings MG. Global prevalence and incidence of traumatic spinal cord injury. Clin Epidemiol. 2014;6:309–331. https://doi.org/10.2147/CLEP.S68889

Draulans N, Kiekens C, Roels E, Peers K. Etiology of spinal cord injuries in Sub-Saharan Africa. Spinal Cord. 2011;49(12):1148–1154.

Jesuyajolu D, Ayantayo T, Oyesiji E, Bakare S, Madeleine O, Adewale O, et al. Burden of traumatic spinal cord injury in Sub-Saharan Africa: a scoping review. World Neurosurg. 2023;179:216–221.e2.

Rupp R, Biering-Sørensen F, Burns SP, Graves DE, Guest J, Jones L, et al. International Standards for Neurological Classification of Spinal Cord Injury: revised 2019. Top Spinal Cord Inj Rehabil. 2021;27(2):1–22. https://doi.org/10.46292/sci2702-1

Fehlings MG, Vaccaro A, Wilson JR, Singh A, Cadotte DW, Harrop JS, et al. Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS). PLoS One. 2012;7(2):e32037.

Badhiwala JH, Wilson JR, Witiw CD, Harrop JS, Vaccaro AR, Aarabi B, et al. The influence of timing of surgical decompression for acute spinal cord injury: a pooled analysis of individual patient data. Lancet Neurol. 2021;20(2):117–126.

Fehlings MG, Tetreault LA, Wilson JR, Kwon BK, Burns AS, Martin AR, et al. A Clinical Practice Guideline for the Management of Patients With Acute Spinal Cord Injury and Central Cord Syndrome: Recommendations on the Timing (≤24 Hours Versus >24 Hours) of Decompressive Surgery. Global Spine J. 2017;7(3 Suppl):195S–202S.

Ter Wengel PV, De Witt Hamer PC, Pauptit JC, van der Gaag NA, Oner FC, Vandertop WP. Early surgical decompression improves neurological outcome after complete traumatic cervical spinal cord injury: a meta-analysis. J Neurotrauma. 2019;36(6):835–844.

Batchelor PE, Wills TE, Skeers P, Battistuzzo CR, Macleod MR, Howells DW, et al. Meta-analysis of pre-clinical studies of early decompression in acute spinal cord injury: a battle of time and pressure. PLoS One. 2013;8(8):e72659.

Vaccaro AR, Oner C, Kepler CK, Dvorak M, Schnake K, Bellabarba C, et al. AOSpine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers. Spine (Phila Pa 1976). 2013;38(23):2028–2037.

Vaccaro AR, Koerner JD, Radcliff KE, Oner FC, Reinhold M, Schnake KJ, et al. AOSpine subaxial cervical spine injury classification system. Eur Spine J. 2016;25(7):2173–2184. https://doi.org/10.1007/s00586-015-3831-3

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement. Lancet. 2007;370(9596):1453–1457.

Zuckerman SL, Haghdel A, Lessing NL, Carnevale J, Cheserem B, Lazaro A, et al. Cervical spine trauma in East Africa: presentation, treatment, and mortality. Int J Spine Surg. 2021;15(5):879–889. https://doi.org/10.14444/8113

Djoubairou BO, Figuim B, Koulagna BG, Haman Nassourou O, Lonzi Teukeu DC, Djientcheu VdP. Surgical outcomes of patients with traumatic spinal cord injuries in three referral hospitals in Cameroon: retrospective study. Ann Afr Surg. 2026;23(2):55–64. https://doi.org/10.4314/aas.v23i2.4

Lehre MA, Eriksen LM, Tirsit A, Bekele S, Petros S, Park KB, et al. Outcome in patients undergoing surgery for spinal injury in an Ethiopian hospital. J Neurosurg Spine. 2015;23(6):772–779.

Nwankwo OE, Uche EO. Epidemiological and treatment profiles of spinal cord injury in southeast Nigeria. Spinal Cord. 2013;51(6):448–452.

Chhabra HS, Arora M. Neglected traumatic spinal cord injuries: causes, consequences and outcomes in an Indian setting. Spinal Cord. 2013;51(3):238–244.

Ikwuegbuenyi CA, Woodfield J, Waterkeyn F, Zuckerman SL, Cheserem B, Leidinger A, et al. Is mechanism of injury associated with outcome in spinal trauma? An observational cohort study from Tanzania. PLoS One. 2024;19(7):e0306577. https://doi.org/10.1371/journal.pone.0306577

Mengesha MG, Baz S, Damenu H, Hanks HJ, Beyer R, Nazareth A, et al. Traumatic spine injury in Southern Ethiopia: falls, delayed presentation, and high early mortality at a tertiary referral center. J Clin Med. 2026;15(9):3276. https://doi.org/10.3390/jcm15093276

Dewan MC, Rattani A, Fieggen G, Arraez MA, Servadei F, Boop FA, et al. Global neurosurgery: the current capacity and deficit in the provision of essential neurosurgical care. J Neurosurg. 2019;130(4):1055–1064.

Park KB, Johnson WD, Dempsey RJ. Global neurosurgery: the unmet need. World Neurosurg. 2016; 88:32–35.