

# The Milan Complexity Scale: A New Tool to Evaluate Complexity and Predict Outcome in Brain Tumor Surgery

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#### Introduction

Assessing complexity and measuring outcome is mandatory to evaluate quality in neurosurgery. A new practical grading scale to estimate the risk of worsening in brain tumor surgery, the Milan Complexity Scale (MCS), is presented. Definition and classification of complications are discussed too.

Sample description: 746 patients			
Variable	Valuo*		
Valiable	value		
Mala	240 (46 9)		
Fomalo	349 (40.0)		
	397 (33.2)		
Moon + SD	51 3 + 171		
Range	1_87		
Histology	1-07		
Meningioma	213 (28.6)		
Glioblastoma	180 (24.1)		
Adenoma	63 (8.4)		
Anaplastic astrocytoma	60 (8.0)		
Low-grade glioma	54 (7.2)		
Metastasis	46 (6 2)		
Schwannoma	35 (4.7)		
Dermoid & epidermoid cysts	21 (2.8)		
Chordoma	11 (1.5)		
Craniopharyngioma	10 (1.3)		
Other	53 (7.1)		
Type of surgery			
Craniotomy for tumor removal	661 (88.6)		
Endoscopic endonasal tumor resection	85 (11.4)		

## Methods

All elective brain tumor surgeries conducted at a tertiary referral center in Milan (Istituto Neurologico C. Besta) in a 2 years period were considered; surgery was always aimed at maximal safe resection (i.e. biopsies excluded). A prospective database dedicated to reporting complications and all clinical and radiological data were retrospectively reviewed. Complications were recodered by means of the Landriel-Ibanez (ref 2) and an etiological classification. The Karnofsky Performance Scale (KPS) was used to classify each patient's health status. A logistic regression model was used to identify possible predictors of clinical worsening after surgery in terms of changes between the preoperative and discharge KPS scores. Statistically significant predictors were rated based on their odds ratios to build an ad hoc complexity scale.

### Results

The case series was composed of 746 patients (Figure 1). The mortality rate was 0.94%, the major complication rate was 9.1%, and the minor complication rate was 32.6%. Details of complications according to Landriel-Ibanez and etiological classification is reported in figure 2. At discharge, 523 (70.1%) patients improved or remained unchanged and 223 (29.9%) patients worsened. Five factors were found to be significant predictors of clinical worsening: tumor size>4 cm, cranial nerve manipulation, major brain vessel manipulation, posterior fossa location, and eloquent area involvement (Figure 3). A grading scale, the MCS (Figure 4), was obtained with scores ranging between 0 and 8. Worsened patients showed preoperative MCS significantly higher than improved/unchanged ones. Scores higher than 3 were suggestive of worse clinical outcome.

Figure 2			
Complications classified by requi (Landriel-Ibanez) and by e	nplications classified by required treatment (Landriel-Ibanez) and by etiology		
Classification of Complications	No. of Patients (%		
Required treatment*			
Grade I	216 (69.4)		
Grade la	120		
Grade Ib	96		
Grade II	69 (22.2)		
Grade IIa	19		
Grade IIb	50		
Grade III	19 (6.1)		
Grade Illa	16		
Grade IIIb	3		
Grade IV	7 (2.3)		
Etiological categories†			
Traumatic	166 (53.4)		
CSF related	43 (13.8)		
Septic	36 (11.6)		
Ischemia	26 (8.4)		
Hemorrhagic	20 (6.4)		
General medicine (extra-CNS) complications	19 (6.1)		
Epilepsy	12 (3.9)		
Other	7 (2.2)		

## Conclusions

The MCS (Ref 1) enables to assess complexity and to estimate the risk of clinical worsening after brain tumor surgery. It is currently under internal and external validation. It could reveal a useful tool for research/educational purposes, for quality evaluation and to improve health system management.

Logistic regression predicting worsening KPS	and associations betw	d	
odemographic and neurosurgical variables* Factor	B Value (SE)	OR (95% CI)	p Value
Constant	-2 88 (0.40)		<0.00
Surgery in eloquent area (including brainstem)			
No (reference)	-		_
Yes	1.93 (0.20)	6.71 (4.65-10.28)	<0.00
Major brain vessels manipulation			
No (reference)	-		-
Yes	0.53 (0.26)	1.69 (1.02-2.83)	0.04
Cranial nerve manipulation			
No (reference)	-	-	-
Yes	1.47 (0.25)	4.34 (2.62-7.17)	<0.00
Tumor size			
0-4 cm (reference)	-	-	-
≥4.1 cm	0.67 (0.20)	1.95 (1.33-2.86)	0.00
Age			
0-44 yrs (reference)	-	-	-
45-60 yrs	-0.15 (0.22)	0.86 (0.56-1.32)	0.49
≥61 yrs	0.11 (0.23)	1.12 (0.71-1.76)	0.62
Surgery in posterior fossa			
No (reference)	-		_
Yes	0.70 (0.24)	2.02 (1.26-3.24)	0.00

Milan Complexity Scale		
Variable	Score	
Major brain vessel manipulation		
No	0	
Yes	1	
Posterior fossa		
No	0	
Yes	1	
Cranial nerve manipulation		
No	0	
Yes	2	
Eloquent area		
No	0	
Yes	3	
Tumor size		
0-4 cm	0	
≥4.1 cm	1	
Total score	0-8	

## Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe the importance of preoperative complexity assessment and measuring outcome in oncological surgery

2) Learn how to use the Milan Complexity Scale

3) Identify factors involved in clinical worsening after brain tumor surgery.

#### References

1. Ferroli P, et al. Predicting functional impairment in brain tumor surgery: the Big Five and the Milan Complexity Scale. Neurosug Focus. 2015 39(6):E14.

2. Landriel Ibañez FA, et al: A new classification of complications in neurosurgery. World Neurosurg 2011 75:709–715.

3. Sarnthein J, et al Patient Registry to Improve Patient Safety: Recording General Neurosurgery Complications. PLoS One. 2016 26;11(9):e0163154.