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Review Article

Outcome measures in neurosurgery: Is a unified approach better? A literature review

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ABSTRACT

Background: Accurate assessment and evaluation of health interventions are crucial to evidence-based care. The use of outcome measures in neurosurgery grew with the introduction of the Glasgow Coma Scale. Since then, various outcome measures have appeared, some of which are disease-specific and others more generally. This article aims to address the most widely used outcome measures in three major neurosurgery subspecialties, "vascular, traumatic, and oncologic," focusing on the potential, advantages, and drawbacks of a unified approach to these outcome measures.

Methods: A literature review search was conducted by using PubMed MEDLINE and Google scholar Databases. Data for the three most common outcome measures, The Modified Rankin Scale (mRS), The Glasgow Outcome Scale (GOS), and The Karnofsky Performance Scale (KPS), were extracted and analyzed.

Results: The original objective of establishing a standardized, common language for the accurate categorization, quantification, and evaluation of patients' outcomes has been eroded. The KPS, in particular, may provide a common ground for initiating a unified approach to outcome measures. With clinical testing and modification, it may offer a simple, internationally standardized approach to outcome measures in neurosurgery and elsewhere. Based on our analysis, Karnofsky's Performance Scale may provide a basis of reaching a unified global outcome measure.

Conclusion: Outcome measures in neurosurgery, including mRS, GOS, and KPS, are widely utilized assessment tools for patients' outcomes in various neurosurgical specialties. A unified global measure may offer solutions with ease of use and application; however, there are limitations.

Keywords: Oncologic neurosurgery, Outcome measures, Traumatic neurosurgery, Unified scale, Vascular neurosurgery

INTRODUCTION

The accurate assessment and evaluation of health interventions are a crucial component of evidence-based care.[9] The systematic monitoring and analysis of surgical outcomes were first

proposed by Dr. Earnst Amory Codman in the early 1900s but was met by unwavering resistance. It was not until 1988 that the Outcomes Committee of the American Association of Neurological Surgeons was established.[11] Before the mid-1970s, outcome measures were mostly restricted to objective physiologic findings, such as lab values or mortality rates. However, the value of patients' quality of life and subjective perception of their state of wellness later drew attention to patient-reported clinical outcome measures.[25]

The use of outcome measures in neurosurgery grew in popularity in 1974 with the introduction of the Glasgow Coma Scale. Since then, various outcome measures have appeared, some of which are disease specific — such as the subarachnoid hemorrhage outcome tool — while others are used more generally, such as the health utility index.[29] With time, specific sub-specialized fields in neurosurgery began to develop their own outcome measures, many of which have been validated and used interchangeably as per different physician, hospital, and national preferences. For instance, more than 10 outcome measures have been reported to be used in pediatric stroke studies alone. Meanwhile, nearly 100 different outcome measures have been reported for traumatic brain injuries.[6] With the popularity of different outcome measures, the choice of the tool has become a combination of accepted practice and personal preference.[23] In designing these outcome measures, a balance between two main aims is sought: the comprehensiveness of the outcome measure in accurately describing the patient's status and the efficiency of the outcome measure for routine use in clinical practice. As a result, what was initially sought to be a standardized, global approach to outcome evaluation is now dispersed across practices and unstandardized. In this paper, we will address the most widely used outcome measures in three of the essential subspecialties of neurosurgery — vascular, traumatic, and oncologic — with a focus on the potential, advantages, and drawbacks of a unified approach to outcome measures across neurosurgical subspecialties.

MATERIALS AND METHODS

The PubMed MEDLINE and Google scholar databases were utilized to conduct a literature review. The Modified Rankin Scale (mRS), The Glasgow Outcome Scale (GOS), and The Karnofsky Performance Scale (KPS) data were retrieved and analyzed.

RESULTS

The original goal of establishing a uniform shared language for the precise categorization, quantification, and evaluation of patients' results has been undermined. Furthermore, the KPS may provide a basis for establishing a unified approach to outcome measures. It may provide a straightforward, internationally standardized approach to outcome measurements in neurosurgery and elsewhere after clinical testing and customization. In addition, based on our analysis, the KPS may provide a basis for establishing a unified global measure.

DISCUSSION

Vascular neurosurgery – The mRS

Vascular neurosurgery is mainly concerned with managing aneurysmal disease, vascular malformation, and ischemic and hemorrhagic stroke. One of the commonly used tools in vascular neurosurgery and especially in stroke trials is the mRS.[31] In 1957, Rankin introduced the Rankin Scale to provide an ultimate prognosis for those suffering from a significant cerebrovascular accident.[32] The scale primarily had five gradings that ranged from "1: No significant disability despite symptoms, able to carry out all usual duties and activities" to "5: Severe disability, bedridden, incontinent, requiring constant nursing care, and attention."[42] In 1988, the Rankin Scale was modified by the United Kingdom Transient Ischaemic Attack trial to include an additional score, "0: No symptom at all."[34,41] A further score, "6: Dead," was added in the 2000s for reliability purposes, delivering the mRS in its current final form.[44]

Primarily, the mRS has been used in adult cerebrovascular disease, particularly in stroke trials.[1] Furthermore, It also has minimal usage in aneurysmal pathologies.[33] On the other hand, other alternative applications for mRS include general brain injury, trials for targeted hypothermia, sarcopenia, spinal meningiomas, and in children with transverse myelitis.[5,10,17,20,21,24,35] The broad use of the mRS is likely due to its simplicity and transferability as a general measure for the extent of disability.

Traumatic neurosurgery – The GOS

Traumatic neurosurgery is mainly concerned with the management of all blunt and penetrating brain injuries. Outcome measures for traumatic brain injury (TBI) exceed any other neurosurgical sub-specialty, with close to 100 measures.[26] The tools used in TBI may differ regarding acute versus long-term outcomes and mild to severe TBI. Each class of outcome measures has a role in different research settings and patient conditions. However, one of the usually used measures is the GOS and GOS Extended (GOSE),[36] which has been argued to be a near complete instrument, in combination with neuropsychological tests, for the assessment of outcome after TBI.[43]

The GOS was first described in 1975 by Drs Bryan Jennet and Michael Bond.[13] It was intended as an objective description of functional recovery following severe brain

damage. The original GOS was scored on a five-point scale: death, persistent vegetative state, severe disability, moderate disability, and good recovery.[45] The seven-point extended version of GOSE was introduced in 1998 as a more accurate classification of functional recovery post-TBI by dividing moderate and severe disability into upper and lower limbs.[13] Moreover, the GOS and GOSE measures have continued to be used in line with their original aim, which is traumatic head injuries.[27] However, the generality of the scale and the broad involvement of TBIs has allowed for applying GOS in several other areas, such as intracranial aneurysms, tumors, strokes, and cranioplasties.[12,14,16,40]

Oncologic neurosurgery – The KPS

Oncologic neurosurgery is mainly concerned with the management of all intracranial neoplastic tumors. Outcome measures of this subspecialty are crucial to assess the patient's response to different treatments. The KPS is one of the oldest, most widely used, and evaluated outcome measures in oncology. Its uses have ranged from treatment planning to prognostic assessments.[19,38,46]

In 1948, the KPS was introduced by Dr. David Karnofsky to evaluate patients undergoing treatment with nitrogen mustard for bronchogenic carcinoma.[15,39] KPS was intended as an indicator of performance status, an attempt to quantify general well-being and activities of daily living. Further, this was particularly useful when other objective measures, such as survival time, were not as easily measurable.[15] The inter-rater reliability of KPS proved high in several studies.[47] Its construct validity was also found to be strongly associated with measures of patients' functioning.[28]

Primarily, the KPS has been widely used to measure cancer patients' functioning and the extent of disability. This has ranged widely from the brain to prostate cancer.[18] As a generally applicable measure of disability, the KPS has found its way to settings of palliative care, geriatric population, musculoskeletal injury, and cerebrovascular surgery.[2-4,22,37,48]

A comparative analysis

All three discussed scales are the most popular outcome measures in the major subspecialties of adult neurosurgery (vascular, traumatic, and oncologic) as examples of common targets between them which are the consciousness status and the neurological deficit measures. The oldest one of these three measures is the KPS (1948) followed by mRS (1957) and finally GOSE (1998). In terms of simplicity, the mRS is relatively the least comprehensive of the three tools, scored on a 7-point scale of which two are 'no symptoms and 'death', whereas the KPS, scored on a 10-point scale with specific criteria, is the most comprehensive one. The GOSE, in terms of simplicity versus comprehensiveness, is most closely similar to the mRS. However, the GOSE is the only scale of the three to differentiate between upper and lower limb disability, which may offer an advantage for an accurate assessment of these regions. For both the KPS and GOSE scales, a higher number indicates a better state, whereas for the mRS a higher number indicates worse status.

The KPS offers the most patient-friendly utility in terms of communication with patients and relatives. Moreover, this is due to its structure as a "percentage of ability" where 100% refers to a disease-free individual, 50% is a disabled person requiring hospitalization or the equivalent, unable to care for themselves, and 0% is a dead individual. As such, the KPS can be argued to be the most intuitive of the three. In addition, while the mRS focuses mainly on the ability to care for oneself and ambulate, the KPS and GOSE differentiate between various forms of "self-care" that fall under activities of daily living, such as being able to resume work and previous activities [Table 1]. In one study done by Gaastra *et al*. where they performed an intersection and correlation analysis between mRS and GOS retrospectively in 3474 paired recordings of the patients.[8] They found that the two outcome scores are correlated, and they in optimal agreement when mRS is two and GOS is 4–5. In addition, mRS to GOS conversion was found to be superior to the reverse option when it was available.[8] This study enriches the discussion between outcome measures on a deeper level and shows variability between them in a detailed manner.

Regarding the reliability and validity of each measure, it is difficult to compare and draw conclusions due to the wide variation in study designs and findings in the literature over the years. Therefore, to accurately compare each measure, validity and reliability study needs to be conducted for all three measures under the same conditions.

It is worth noting that all three scales serve the same purpose at the core: describing and classifying a patient's functional and physical abilities. However, none of the scales measure psychosocial aspects of disease and recovery.

Potential, advantages, and disadvantages of a unified outcome measure

With over 100 different outcome measures in the literature, the original objective of establishing a standardized, common language for accurately categorizing, quantifying, and evaluating patients' outcomes which have been eroded. For this reason, a call for a unified approach to outcome measures is warranted.

By reviewing the history of origin for the three commonest scales, it becomes clear that the main factor behind the use of these scales in a specific field can be traced back to their initial historical use. Naturally, when a researcher publishes

Table 1: A comparative analysis of the most common outcome measures in the neurosurgical subspecialties.

Scale	Designed aim	Primary application	Scoring system	Alternative application
GOS	Assess the functional recovery of patients after severe brain damage[13]	Severe brain damage after traumatic brain injury[13]	1=Dead 2=Persistent neurovegetative state (patient unresponsiveness and speechless for weeks or months) 3=Severe disability (conscious but dependent for daily support) 4=Moderate disability (disabled but independent in daily life) 5=Good recovery[33]	Intracranial aneurysms, tumors, strokes, and cranioplasties[12,27,46,48]
mRS	Classify functional recovery of patients with cerebrovascular accident at the time of discharge[42]	Assess patients with cerebrovascular disease in adults (>60-years-old) at discharge or referral[42]	0=No symptom at all 1=No significant disability, able to carry out all usual duties and activities. 2=Slight disability, unable to carry out all previous activities but able to look after own affairs without assistance[10] 3=Moderate disability, requires some help but able to walk without assistance 4=Moderately severe disability, unable to walk without assistance and unable to attend to own bodily needs without assistance 5=Severe disability, bedridden, incontinent, and requiring constant nursing care and attention 6=Dead[42]	The mRS has been used in aneurysmal pathologies, general brain injury, trials for targeted hypothermia, sarcopenia, spinal meningiomas, and in children with transverse myelitis[5,10,17,20,21,24,35]
KPS	Assess the functional status of tumours.[39]	Tumors and cancers, particularly in neuro-oncology and following treatment.[39]	100=Normal no complaints: no evidence of disease 90=Able to carry on normal activity; minor signs or symptoms of disease 80=Normal activity with effort; some signs or symptoms of disease. Unable to work; able to live at home and care for most personal needs; varying amount of assistance needed 70=Cares for self; unable to carry on normal activity or to do active work 60=Requires occasional assistance but is able to care for most of his personal needs 50=Requires considerable assistance and frequent medical care. Unable to care for self; requires equivalent of institutional or hospital care; disease may be progressing rapidly 40=Disable: requires special care and assistance 30=Severely disabled: hospital admission is indicated although death not imminent 20=Very sick hospital admission necessary; active supportive treatment necessary 10=Moribund: fatal processes progressing rapidly 0=Dead[3]	The KPS has been widely used as a measure of disability. These include settings of palliative care, geriatric populations, osteoarthritis, and revascularization surgery[2,3,48]

GOS: Glasgow outcome scales, mRS: Modified rankin scale , KPS: Karnofsky performance scale

within their field, their work is disseminated and most likely to influence other researchers and practitioners within the same field. As such, innovations tend to lag in transcending between specialties and sub-specialties, leading to their restricted adoption within the niche community, it was first intended.

As can be drawn from an analysis of the three scales, they are more similar than dissimilar and can be applied equally to each sub-specialty. The KPS, in particular, may provide a common ground for initiating a unified approach to outcome measures. In addition, this unification considers its comprehensiveness, tested reliability and validity,

intuitiveness, broad uses, and clear, descriptive criteria. In addition, the KPS is already used diversely in various fields that deal with cancer and may have the highest tendency of success in new applications. With clinical testing and modification, it may offer a simple, internationally standardized approach to outcome measures in neurosurgery and elsewhere.

The unified global approach to outcome measures may have advantages in clinical practice and research; it facilitates communication, patient handover, and consultations across different sub-specialties and centers and allows for accurate comparisons between trials and patient populations. These considerations may prove highly rewarding concerning patient outcomes, neurosurgeons' practice, and researchers' efforts. On the other hand, a unified approach to outcome measures may not be appropriate in all settings, as subtle differences may be required according to the particular needs of each subspecialty. Moreover, the future direction of measuring the quality of life in neurosurgery is getting more specialized and focused, and there is a need for disease-specific outcome measures to ensure an accurate assessment of the patients.[7] The topic of this paper and its related discussion can be highlighted in the future in a comprehensive systematic review utilizing PRISMA guidelines.[30]

Quality of life as end-point

In modern-day practice, quality of life has become a critical target, particularly in the field of neurosurgery. Schwartz *et al*. pointed out in their study (they utilized mRS scale in the study) on the neurological outcome and quality of life in patients with world federation of neurosurgical societies Grades 4 and 5 aneurysmal subarachnoid hemorrhages in their center that younger ages (<53 years) and radiological absence of cerebral ischemia were significantly associated with favorable outcome in the quality of life.[36] In another study where disease-specific outcome measure was used, Foscolo *et al*. examined the quality of life in patients after vestibular schwannoma surgery.[7] They reached the conclusion that the quality of life of the selected patients after the surgery was acceptable in most of the domains, with other ones being more affected, such as hearing and balance. Vestibular rehabilitation programs and effective strategies to tackle hearing problems are recommended for post-operative cases with low scores.[7] The generated discussion in the literature is may pinpoint the need for disease-specific outcome measures to gain a more reliable measure of the intervention and future steps in patients' management.

Limitations

The article represented a narrative review of the literature regarding the outcome measures in neurosurgery; however, a systematic review of the literature on this topic may redeem better cultivation of the subject. Our study focuses on the targets of consciousness status and neurological deficits in the outcome measures, mainly with examples applied in vascular, trauma, and oncology. Moreover, a suggested systematic review in the future that encompasses all the target measures in outcome in all possible sub-specialties within neurosurgery would add more clarification to the debates about the outcome measures.

CONCLUSION

Outcome measures in neurosurgery, like "The Modified Rankin Scale, The Glasgow Outcome Scale, and The Karnofsky Performance Scale" are commonly utilized assessment tools for patients' outcomes in various neurosurgical diseases. A unified global measure may provide a solution with ease of use and application; however, there are limitations.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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