

NEUROCRITICAL CARE THROUGH HISTORY



Idiosyncrasies of Outcome Grading After Brain Injury: Past into the Present

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Scottish medicine has a rich history of contribution to outcome assessment in traumatic brain injury (TBI) and stroke. Jennett, Bond, and Rankin provided us with scales that are still in use today (albeit in modified versions). In this article, I will review these scales from an historical perspective and how they came about in a rapidly changing hospital environment, with special units for critically ill and neurocritically ill patients.

Outcomes and rehabilitation are, of course, intricately linked, and an earlier landmark development occurred in the field of physical medicine in 1943 with the establishment of the Baruch Committee on Physical Medicine. The Baruch Committee was the major vehicle for the advancement of physical medicine as a medical specialty in the United States. It provided the mission and vision (and resources) necessary for physical medicine physicians to establish their specialty. (Bernard Baruch [1] was a wealthy philanthropist and economic advisor to several United States presidents.) This parallel development was important because patients with acute brain injury required rehabilitation, which later subspecialized into neurorehabilitation. Once intensive care (i.e., mechanical ventilation and systemic and brain resuscitation) permitted survival of patients with major brain injury, there was a need to build data banks, which then needed metrics. In extreme cases, neurologists could determine outcome early, but they could do so more accurately after the patient had been resuscitated and had entered a relatively stable clinical state. Soon, the flaws of applying the classification of new disability to large groups became apparent. Before Jennett and Bond devised a practical scale that later became known as the Glasgow Outcome Scale (GOS), a number of European

scales had attempted to predict outcome in head injury survivors. Previously described outcomes included categories such as “permanent invalid,” “slight sequelae,” “partially reintegrated,” and “mental restitution”; they were all poor interpretations of a patient’s functional well-being or handicap. Pigeonholing a patient’s functionality was too restrictive. When traumatic head injury databases became well organized, there was a simple, practical demand for tools to evaluate outcome and predict futility.

Rating Outcome

Jennett and Bond’s article became known as the GOS and was basically a description of the nature of disability in survivors of brain damage. Its brilliance lies in its simplicity and its systematic listing of functional outcomes. The GOS introduced hierarchical grades; it divided outcome into death or survival and subdivided survival into dependence or independence by creating more subcategories. These spanned from a persistent vegetative state, severe disability, and moderate disability to good recovery. Jennett and Bond used the GOS in their intensive care unit for “some years” and found “a good measure of agreement between different assessors.” No formal studies were presented in this article, but its publication was a landmark development because it elucidated limitations of existing systems, summarized the difficulty in judging disability, and proposed a solution. The authors appropriately emphasized that judging disability might involve a patient component as well as a physician component. In other words, patients may feel markedly handicapped, whereas the neurosurgeon feels that they are doing quite well considering the severity of the injury. The authors also acknowledged that disability might be underestimated and routine encounters with the patient may not reveal the extent of the cognitive deficit. Death requires no

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further description, but the authors were careful to note that death could be ascribable to primary brain damage or, for example, to pneumonia. However, there was (perhaps unfortunately) no clear distinction in the GOS between brain death, death from systemic complications, or withdrawal of support in patients with major complications.

The more difficult categories to assess were severe and moderate disability. Severe disability indicated that patients were dependent on daily care. Patients with moderate disability were independent and could travel alone, although a severe handicap might be present. The good recovery category was usually seen as “resumption of normal life,” with minor neurological or psychological deficits. The authors also declared that return to work was a poor measure of recovery, particularly if patients returned with markedly curtailed responsibilities. Moreover, the distinction between nursing home placement or returning home might be a factor of family support rather than degree of disability. Good recovery was just as difficult a category as persistent vegetative state, certainly because persistent vegetative state was a rare occurrence—then and now (Fig. 1).

Acceptance

The GOS was less universally accepted than the Glasgow Coma Scale, and many other outcome scales have been developed. Nonetheless, the contribution was quite significant for dividing disability into dependence (assistance with personal needs) and independence (the ability to look after oneself). Subsequent work and use in clinical trials proved its utility [2, 3].

The GOS has remained a preferred outcome system in assessing patients with traumatic head injury, particularly in Europe and the UK. The scales have become universal metrics for patients with severe brain injury. In his article in 1978, Langfitt forcefully stated:

“The author believes that the Glasgow Coma Scale and the Glasgow outcome measures should be adopted by neurosurgical units throughout the world to evaluate their patients with head injuries. Since other coma scales have merit, and changes such as the recent addition of a 15th point undoubtedly will be made in the Glasgow Coma Scale, there should be agreement to adopt the Coma Scale for a specified period of time, perhaps a 5-year period from 1978 through 1982. During that time, the applicability of the Coma Scale can be thoroughly tested and suggested changes cataloged in a central location [4].”

Table 4 Glasgow-Pittsburgh Outcome Categories of Brain Injury^a

Cerebral Performance Categories (CPC)	Overall Performance Categories (OPC)
1. <i>Good Cerebral Performance:</i> Conscious, alert, able to work and lead a normal life. May have minor psychologic or neurologic deficits (mild dysphasia, nonincapacitating hemiparesis, or minor cranial nerve abnormalities).	1. <i>Good Overall Performance:</i> Healthy, alert, capable of normal life. Good cerebral performance (CPC 1) plus no functional disability from noncerebral organ system abnormalities.
2. <i>Moderate Cerebral Disability:</i> Conscious. Sufficient cerebral function for part-time work in sheltered environment or independent activities of daily life (dress, travel by public transportation, food preparation). May have hemiplegia, seizures, ataxia, dysarthria, dysphasia, or permanent memory or mental changes.	2. <i>Moderate Overall Disability:</i> Conscious. Moderate cerebral disability (CPC2) alone or moderate disability from noncerebral system dysfunction alone or both. Performs independent activities of daily life (dress, travel, food preparation) or able to work part-time in sheltered environment, but disabled for competitive work.
3. <i>Severe Cerebral Disability:</i> Conscious; dependent on others for daily support (in an institution or at home with exceptional family effort). Has at least limited cognition. This category includes a wide range of cerebral abnormalities, from patients who are ambulatory but have severe memory disturbance or dementia precluding independent existence, to those who are paralyzed and can communicate only with their eyes, as in the locked-in syndrome.	3. <i>Severe Overall Disability:</i> Conscious. Severe cerebral disability (CPC 3) alone or severe disability from noncerebral organ system dysfunction alone, or both. Dependent on others for daily support.
4. <i>Coma/Vegetative State:</i> Unconscious, unaware of surroundings, no cognition. No verbal and/or psychologic interaction with environment.	4. Same as CPC 4.
5. <i>Brain Death:</i> Certified brain dead or dead by traditional criteria.	5. Same as CPC 5.

^aAdapted from Jennett B, Bond M: Assessment of outcome after severe brain damage. *Lancet* 1:480-484, 1975.

Fig. 1 Glasgow Outcome Scale as expanded in Teasdale and Jennet's book. *Management of Head Injuries Contemporary Neurology series* F.A. Davis Company, 1981

While the GOS has remained a preferred outcome system in assessing patients with traumatic head injury, Teasdale et al. [5] published an extended GOS (eight-point version) two decades later. The difficulties documented in applying the GOS consistently might have been exacerbated initially, but standard interview questions improved it greatly [6].

Studies on stroke often apply the Rankin Scale, which was devised by Glaswegian John Rankin during his time in Stobhill Hospital in Glasgow. Rankin created a prototypic stroke unit and promoted ideals of multidisciplinary work and early rehabilitation to remain core principles of contemporary stroke care [7] (Table 1). The development of multicenter interventional trials led to the “rediscovery” of Rankin's scale for the first multicenter trial in neurology, the United Kingdom Transient Ischemic Attack study [8]. Rather than develop an instrument de novo, they turned to Rankin's eponymous scale. Following initial pilot work, the United Kingdom Transient Ischemic Attack team revised the

Table 1 The original Rankin Scale

Grade	Description
Grade I	No significant disability, able to carry out all usual duties
Grade II	Slight disability, unable to carry out some of previous activities but able to look after own affairs without assistance
Grade III	Moderate disability, requiring some help but able to walk without assistance
Grade IV	Moderately severe disability, unable to walk without assistance and unable to attend to own bodily needs without assistance
Grade V	Severe disability, bedridden, incontinent, and requiring constant nursing care and attention

wording of Rankin's original gradings to allow for better reliability—the modified Rankin Scale. The scale was then subjected to an interobserver variability study [9], and the success of these trials alerted the stroke community to the utility of Rankin's scale. The modified Rankin Scale provides sufficient discrimination, but with complex disability, comprehensive scales are warranted.

The Cerebral Performance Category (CPC) was introduced in CPR trial [10]. The Pittsburgh modification, first used in the BRCT I, separates level of function into cerebral and overall performance categories. They wrote, “to ensure that the CPC score was being applied consistently, its components were reviewed before the start of the trial and at each annual investigator meeting.” In addition, each CPC and OPC score was evaluated centrally in Pittsburgh. The reviewing physician determined the patient's CPC on the basis of available information. Disagreements between investigator and reviewer on CPC scores were discussed and adjudicated. This adjudication served as the major quality control for the measurement of CPC. Later studies confirmed good reliability [11].

The CPC and Rankin Scale in later studies have been used more often, although they are basically modifications of the GOS. The CPC is most often used in studies of anoxic-ischemic encephalopathy. Albeit appropriately validated, the instruments that assess clinical outcomes vary considerably among studies and even in studies with the same patient populations. The GOS was nearly forgotten due to a radical takeover of the CPC, but the original GOS remained active in the two major TBI data banks (IMPACT and CRASH). The extended GOS (GOSE) has become widely adopted in TBI research studies and is used in the present day and in UK-originated and European Union-originated clinical trials on TBI [12, 13]. GOSE ratings of TBI outcomes obtained from questionnaires and interviews had good overall agreement [14]. Trialists and data base interpreters have to be thoroughly

equipped for the job. Fortunately, this was recognized early. And yet, we can contend that many outcome scales in clinical trials including acute brain injury do not account for nuance and fall short. Progress since the mid-20th century has stagnated.

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References

1. Baruch Committee on Physical Medicine. Annual report of the Baruch Committee on Physical Medicine. University of Iowa; 1944.
2. Bond MR, Jennett WB, Brooks DN, McKinlay W. The nature of physical, mental and social deficits contributing to the categories of good recovery, moderate and severe disability in the Glasgow Global Outcome Scale. *Acta Neurochir Suppl (Wien)*. 1979;28(1):126–7.
3. Teasdale G, Jennett B. Assessment and prognosis of coma after head injury. *Acta Neurochir (Wien)*. 1976;34(1–4):45–55.
4. Langfitt TW. Measuring the outcome from head injuries. *J Neurosurg*. 1978;48(5):673–8.
5. Teasdale GM, Pettigrew LE, Wilson JT, Murray G, Jennett B. Analyzing outcome of treatment of severe head injury: a review and update on advancing the use of the Glasgow Outcome Scale. *J Neurotrauma*. 1998;15(8):587–97.
6. Wilson JT, Pettigrew LE, Teasdale GM. Structured interviews for the Glasgow Outcome Scale and the extended Glasgow Outcome Scale: guidelines for their use. *J Neurotrauma*. 1998;15(8):573–85.
7. Quinn TJ, Dawson J, Walters M. Dr John Rankin; his life, legacy and the 50th anniversary of the Rankin Stroke Scale. *Scott Med J*. 2008;53(1):44–7.
8. UK-TIA Study Group. United Kingdom transient ischemic attack (UK-TIA) aspirin trial: interim results. *UK-TIA Study Group Br Med J (Clin Res Ed)*. 1988;296(6618):316–20.
9. van Swieten JC, Koudstaal PJ, Visser MC, Schouten HJ, van Gijn J. Interobserver agreement for the assessment of handicap in stroke patients. *Stroke*. 1988;19(5):604–7.
10. The Brain Resuscitation Clinical Trial II Study Group. A randomized clinical trial of calcium entry blocker administration to comatose

-
- survivors of cardiac arrest. Design, methods, and patient characteristics. The Brain Resuscitation Clinical Trial II Study Group. *Control Clin Trials*. 1991;12(4):525–45.
11. Ajam K, Gold LS, Beck SS, et al. Reliability of the Cerebral Performance Category to classify neurological status among survivors of ventricular fibrillation arrest: a cohort study. *Scand J Trauma Resusc Emerg Med*. 2011;19:38.
 12. Hutchinson PJ, Adams H, Mohan M, et al. Decompressive Craniectomy versus craniotomy for acute subdural hematoma. *N Engl J Med*. 2023;388(24):2219–29.
 13. van Erp IAM, van Essen TA, Lingsma H, et al. Early surgery versus conservative treatment in patients with traumatic intracerebral hematoma: a CENTER-TBI study. *Acta Neurochir (Wien)*. 2023;165(11):3217–27.
 14. Horton L, Rhodes J, Menon DK, Maas AIR, Wilson L. Questionnaires vs interviews for the assessment of global functional outcomes after traumatic brain injury. *JAMA Netw Open*. 2021;4(11):e2134121.