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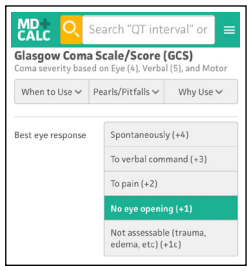

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Glasgow Coma Scale

The Glasgow coma scale (GCS) estimates coma severity based on eye, verbal, and motor criteria.

Points & Pearls

- The Glasgow coma scale (GCS) allows providers in multiple settings and with varying levels of training to communicate succinctly about a patient's mental status.
- The GCS has been shown to have a statistical correlation with a broad array of adverse neurologic outcomes, including brain injury, need for neurosurgery, and mortality.
- The GCS has been incorporated into numerous guidelines and assessment scores (eg, ACLS, ATLS, APACHE I-III, TRISS, and the WNS SAH grading scale).
- In some patients, it may be impossible to assess 1 or more of the 3 components of the GCS. The reasons for this include, but are not limited to:
  - **Eye:** local injury and/or edema
  - **Verbal:** intubation
  - **All (eye, verbal, motor):** sedation, paralysis, and ventilation that eliminates all responses
- If a component of the GCS is untestable, a score of 1 should not be assigned (Teasdale 2014). In this circumstance, summation of the components for a total GCS score is invalid.
- The 3 parts of the GCS are charted independently, and a component can be recorded as *NT* (not testable), with an option of indicating the reason (eg, *C* for eye closure and *T* for intubation).

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Points to keep in mind:

- Correlation with outcome and severity is most accurate when applied to an individual patient over time; the patient's trend is important.
- A GCS score of 8 should not be used in isolation to determine whether or not to intubate a patient, but does suggest a level of obtundation that should be evaluated carefully.
- Reproducibility is usually good (Reith 2016). If individual institutions have concerns about agreement among providers, training and education are available from the GCS creators at www.glasgowcomascale.org.
- Simpler scores that have been shown to perform as well as the GCS in the prehospital and emergency department setting (for initial evaluation); these are often contracted versions of the GCS itself. For example, the Simplified Motor Score (SMS) uses the motor portion of the GCS only. The SMS and other contracted scores are less well studied than the GCS for outcomes like long-term mortality, and the GCS has been studied as trended over time, while the SMS has not.

Critical Actions

Although it has been adopted widely and in a variety of settings, the GCS score is not intended for quantitative use. Clinical management decisions should not be based solely on the GCS score in the acute setting.

Evidence Appraisal

The modified GCS (the 15-point scale that has been widely adopted, including by the original unit in Glasgow, as opposed to the 14-point original

Why to Use

The GCS score is an adopted standard for mental status assessment in the acutely ill trauma and nontrauma patient and assists with predictions of neurological outcomes (complications, impaired recovery) and mortality.

When to Use

- The GCS is designed for use in serial assessments of patients with coma from either medical or surgical causes and is widely applicable.
- The GCS is commonly used in the prehospital and acute care setting as well as over a patient's hospital course to evaluate for mental status assessment in both traumatic and nontraumatic presentations.
- In the care of an individual patient, the scoring for each of the 3 components of the GCS (eye, verbal, motor) should be assessed, monitored, reported, and communicated separately.
- The combined GCS score is an index of the net severity of impairment and is useful as a summary of a patient's condition, in classifying groups of different severity, for triage, and in research. A GCS score should not be calculated if 1 or more of the components cannot be assessed.

Next Steps

- The GCS can indicate the level of critical illness.
- Trauma patients presenting with a GCS score < 15 warrant close attention and reassessment.
- A declining GCS score is concerning in any setting, and should prompt airway assessment and possible intervention.
- Conversely, a GCS score of 15 should not be taken as an indication that a patient (trauma or medical) is not critically ill. Decisions about the aggressiveness of management and treatment plans should be made based on clinical presentation and context, and should not be overridden in any way by the GCS score.
- Clinical management decisions should not be based solely on the GCS score in the acute setting.
- If a trauma patient has a GCS score < 8 and there is clinical concern that the patient is unable to protect his/her airway or there is an expected worsening clinical course based on exam or imaging findings, then intubation can be considered.
- In any patient, a rapidly declining or waxing and waning GCS score is concerning and intubation should be considered in the context of the patient's overall clinical picture.

Abbreviation: GCS, Glasgow coma scale.

GCS) was developed to be used in a repeated manner in the inpatient setting to assess and communicate changes in mental status and to measure the duration of coma (Teasdale 1974).

The evidence presented in 53 published reports on the reproducibility of the GCS was synthesized in a systematic review by Reith et al in 2016. Eighty-five percent of the findings in the studies identified as high quality showed substantial reliability of the GCS as judged by the standard criterion of a kappa statistic > 0.6. Reproducibility of the total GCS score was also high, with kappa > 0.6 in 77% of the observations. Education and training on usage of the GCS resulted in a clear beneficial effect on reliability (Reith 2016).

In its most common usage, the 3 sections of the scale are often combined to provide a summary of severity. The authors themselves have explicitly objected to the score being used in this way, and analysis has shown that patients with the same total score can have huge variations in outcomes, specifically mortality. A GCS score of 4 predicts a mortality rate of 48% if calculated 1 + 1 + 2 for eye, verbal, and motor components, respectively, and a mortality rate of 27% if calculated 1 + 2 + 1, but a mortality rate of only 19% if calculated 2 + 1 + 1 (Healey 2014).

The modified GCS provides a nearly universally-accepted method of assessing patients with acute brain damage. Summation of its components into a single overall score loses information and provides only a rough guide to severity. In some circumstances, such as early triage of severe injuries, assessment of only a contracted version of the motor component of the scale (as in the SMS) can perform as well as the GCS and is less complicated. However, the scores like the SMS may be less informative in patients with lesser injuries.

Use the Calculator Now

Click here to access the GCS on MDCalc.

Calculator Creator

Sir Graham Teasdale, MBBS, FRCP
Click here to read more about Dr. Teasdale.

References

Original/Primary Reference

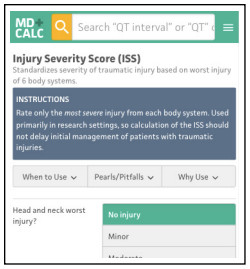
- Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. *Lancet.* 1974;2(7872):81-84. **DOI:** https://doi.org/10.1016/s0140-6736(74)91639-0

Validation References

- Moore L, Lavoie A, Camden S, et al. Statistical validation of the Glasgow Coma Score. *J Trauma.* 2006;60(6):1238-1243. **DOI:** https://doi.org/10.1097/01.ta.0000195593.60245.80
- Reith FC, Van den Brande R, Synnot A, et al. The reliability of the Glasgow Coma Scale: a systematic review. *Intensive Care Med.* 2016;42(1):3-15. **DOI:** https://doi.org/10.1007/s00134-015-4124-3

Other References

- Teasdale G, Jennett B. Assessment of coma and severity of brain damage. *Anesthesiology.* 1978;49(3):225-226. **DOI:** https://doi.org/10.1097/00000542-197809000-00023
- Teasdale G, Jennett B, Murray L, et al. Glasgow coma scale: to sum or not to sum. *Lancet.* 1983;2(8351):678. **DOI:** https://doi.org/10.1016/s0140-6736(83)92550-3
- Healey C, Osler TM, Rogers FB, et al. Improving the Glasgow Coma Scale score: motor score alone is a better predictor. *J Trauma.* 2003;54(4):671-678. **DOI:** https://doi.org/10.1097/01.TA.0000058130.30490.5D
- Green SM. Cheerio, laddie! Bidding farewell to the Glasgow Coma Scale. *Ann Emerg Med.* 2011;58(5):427-430. **DOI:** https://doi.org/10.1016/j.annemergmed.2011.06.009
- Middleton PM. Practical use of the Glasgow Coma Scale; a comprehensive narrative review of GCS methodology. *Australas Emerg Nurs J.* 2012;15(3):170-183. **DOI:** https://doi.org/10.1016/j.aenj.2012.06.002
- Yeh DD. Glasgow Coma Scale 40 years later: in need of recalibration?. *JAMA Surg.* 2014;149(7):734. **DOI:** https://doi.org/10.1001/jamasurg.2014.47
- Teasdale G. Forty years on: updating the Glasgow Coma Scale. *Nurs Times.* 2014;110(42):12-16. https://www.nursingtimes.net/clinical-archive/accident-and-emergency/forty-years-on-updating-the-glasgow-coma-scale-10-10-2014/
- Gill M, Windemuth R, Steele R, et al. A comparison of the Glasgow Coma Scale score to simplified alternative scores for the prediction of traumatic brain injury outcomes. *Ann Emerg Med.* 2005;45(1):37-42. **DOI:** https://doi.org/10.1016/j.annemergmed.2004.07.429
- Haukoos JS, Gill MR, Rabon RE, et al. Validation of the Simplified Motor Score for the prediction of brain injury outcomes after trauma. *Ann Emerg Med.* 2007;50(1):18-24. **DOI:** https://doi.org/10.1016/j.annemergmed.2006.10.004
- Thompson DO, Hurtado TR, Liao MM, et al. Validation of the Simplified Motor Score in the out-of-hospital setting for the prediction of outcomes after traumatic brain injury. *Ann Emerg Med.* 2011;58(5):417-425. **DOI:** https://doi.org/10.1016/j.annemergmed.2011.05.033
- Teasdale G, Maas A, Lecky F, et al. The Glasgow Coma Scale at 40 years: standing the test of time. *Lancet Neurol.* 2014;13(8):844-854. **DOI:** https://doi.org/10.1016/S1474-4422(14)70120-6



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Injury Severity Score (ISS)

The Injury Severity Score (ISS) standardizes the severity of traumatic injury based on the 3 worst injuries from 6 body systems.

Points & Pearls

- The Injury Severity Score (ISS) was initially derived in patients with blunt traumatic injury from motor vehicle accidents.
- The ISS is not intended to be used for bedside decision-making for a single patient in the emergency department setting, but rather as a tool to standardize the study of trauma patients.
- Due to the nature of the score, multiple combinations of Abbreviated Injury Scale (AIS) scores may result in the same ISS, each of which may indicate a different mortality rate. For example, an ISS of 17 can be calculated from patients with a combination of points based on the 3 most severe injuries, such as (4, 1, 0) or (3, 2, 2). The ISS assigns equal value to each body region.

Instructions

First, the most severe injury from each of 6 body systems is assigned an AIS score on a scale of 0 (no injury) to 6 (unsurvivable injury). Next, those scores are used to determine the 3 most injured body systems. Finally, the ISS is calculated by squaring the AIS score for each of the 3 most injured body systems, then adding up the 3 squared numbers ($A^2 + B^2 + C^2$ = ISS, where A, B, and C are the AIS scores of the most severe injury in each of the 3 most severely injured body systems). Patients with an AIS of 6 in any body system are automatically assigned an ISS of 75, the maximum possible score.

The ISS is used primarily in research settings, so calculation of the score should not delay initial management of patients with traumatic injuries.

Critical Actions

- In all trauma patients, the initial treatment strategy should focus on the primary and secondary survey, and assessing and stabilizing the patient.

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Why to Use

Due to the heterogeneous nature of trauma patients, standardizing the severity of traumatic injuries allows for comparison of much larger sample populations in trauma research studies.

When to Use

The ISS attempts to standardize the severity of injuries sustained during trauma. This standardization allows for more accurate study and prediction of morbidity and mortality outcomes after traumatic injuries.

Next Steps

As the ISS is intended primarily as a research tool, the score should not affect the initial management of a patient with traumatic injuries.

Abbreviation: ISS, Injury Severity Score.

- Although the ISS score is intended primarily for research purposes, it may have broader clinical use in the intensive care unit for prognostication following the initial stabilization of traumatic injuries.

Evidence Appraisal

The ISS was derived by Baker et al (1974) by taking the previously used AIS (American Medical Association Committee on Medical Aspects of Automotive Safety 1971) and adding the squared value of each of the 3 most severely injured body systems, in an effort to add increasing importance to the most severe injuries. The top 3 most severe injuries were used to calculate the final score because it had been shown that injuries that would not necessarily be life-threatening in isolation could have a significant effect on mortality when they occurred in combination with other severe injuries. The derivation study included only injuries sustained from motor vehicle collisions, including the occupants of the vehicles and any pedestrians involved.

Further studies have validated the ISS to include other mechanisms of injury. A study by Beverland et al (1983) of 875 patients with gunshot wounds showed that an increasing ISS was associated with increasing mortality (chi-squared =

83.31, $P < .001$). A study by Bull (1978) confirmed the correlation between increasing ISS and increasing mortality in road traffic accidents, and showed correlation between increasing ISS and increasing mean hospital length of stay.

In a study of 8852 trauma patients from the Illinois Trauma Program (including both vehicular and nonvehicular trauma), Semmlow et al (1976) had similar findings to Baker et al regarding the relationship between ISS and mortality. They also found that the ISS correlated with hospital length of stay.

Use the Calculator Now

Click here to access the ISS on MDCalc.

Calculator Creator

Susan P. Baker, MPH
Click here to read more about Professor Baker.

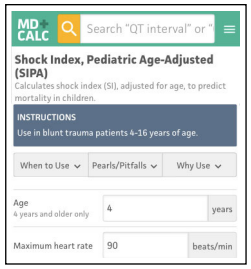
References

Original/Primary Reference

- Baker SP, O'Neill B, Haddon W, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma.* 1974;14(3):187-196. **https://www.ncbi.nlm.nih.gov/pubmed/4814394**

Validation References

- Beverland DE, Rutherford WH. An assessment of the validity of the injury severity score when applied to gunshot wounds. *Injury.* 1983;15(1):19-22. **DOI: https://doi.org/10.1016/0020-1383(83)90156-0**
- Committee on Medical Aspects of Automotive Safety. Rating the severity of tissue damage: I. The abbreviated scale. *JAMA.* 1971;215(2):277-280. **DOI: https://doi.org/10.1001/jama.1971.03180150059012**
- Semmlow JL, Cone R. Utility of the injury severity score: a confirmation. *Health Serv Res.* 1976;11(1):45-52. **https://www.ncbi.nlm.nih.gov/pubmed/965234**
- Bull JP. Measures of severity of injury. *Injury.* 1978;9(3):184-187. **DOI: https://doi.org/10.1016/0020-1383(78)90004-9**
- Copes WS, Champion HR, Sacco WJ, et al. The Injury Severity Score revisited. *J Trauma.* 1988;28(1):69-77. **https://www.ncbi.nlm.nih.gov/pubmed/3123707**



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Shock Index, Pediatric Age-Adjusted (SIPA)

Introduction: The SIPA calculates the shock index, adjusted for age, to predict mortality in children.

Points & Pearls

- The shock index, pediatric age-adjusted (SIPA) should be calculated upon the patient's presentation to the emergency department (ED).
- An upward trending SIPA between the field and the ED may predict a poor outcome, but this was not examined by the original study authors.
- The original study authors indicated that the age-specific cutoffs they chose will require further validation in a second cohort (Acker 2017).
- The use of the SIPA to predict patient morbidity and mortality following admission has not yet been validated. However, a prognostic study by Vandewalle et al (2018) found that patients who developed an elevated SIPA within the first 24 hours of admission were at an increased risk for complications compared to those whose SIPA remained normal throughout the first 48 hours of admission. In addition, the time to normalize SIPA directly correlated with the length of hospital stay and length of stay in the intensive care unit.

Advice

Patients who present with an elevated SIPA for age have a higher risk of morbidity and mortality following blunt trauma. Early recognition and treatment of these patients, including a possible decision to transfer to a higher level of care, will improve outcomes.

Critical Actions

There is no value or finding that necessarily defines shock, and children can compensate more readily than adults. Hypotension is often a late finding in children with hypovolemic shock.

Evidence Appraisal

The SIPA was originally developed by researchers at the Children's Hospital of Colorado to help

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Why to Use

The SIPA is more accurate than the SI at differentiating severely injured children from children with mild injury. In the original study (Acker 2015), an elevated SIPA was shown to identify approximately 25% of the most severely injured children, regardless of age, while an SI > 0.9 has been shown to identify anywhere from 32% to 71% of injured children, depending on age. Being able to accurately identify severely injured children is critical in reducing the overtriage of children who have sustained injuries. An elevated SIPA is associated with the following outcomes (Acker 2015; Nordin, Coleman, Shi, et al 2017):

- Higher injury severity
- Need for blood transfusion in the first 24 hours
- Longer intensive care unit and hospital length of stay
- Higher number of ventilator days
- Discharge to a rehabilitation facility
- Increased risk of mortality

When to Use

The SIPA can be used for patients aged 4 to 16 years who have sustained blunt trauma. The SIPA should not be used for young infants, toddlers, or patients with penetrating trauma.

Next Steps

The general management of pediatric blunt abdominal trauma includes performing the primary and secondary surveys and determining the extent, type, and severity of injury.

A thorough abdominal examination is extremely important because abdominal injuries are often not apparent on physical examination. Depending on the examination findings, the use of imaging may be warranted.

Abbreviations: SI, shock index; SIPA, shock index, pediatric age-adjusted.

identify severely injured children following blunt trauma (Acker 2015). Mechanism alone has been found to be a poor predictor of injury severity in children (Qazi 1998). Clinical and physiologic parameters are better indicators (Wang 2001) and previous studies (Rousseaux 2013; Yasaka 2013) have shown that the shock index (SI) helps identify a higher risk of mortality versus using heart rate and blood pressure alone. The SIPA furthers builds on those findings by using specific vital sign cutoffs by age group.

Realizing that pediatric vital signs vary with age and that the SI might not be as useful in children, Acker et al (2015) sought and defined maximum normal heart rate and minimum normal systolic blood pressure using reference ranges from 2 pediatric textbooks and the United States Department of Health and Human Services' Pediatric Basic and Advanced Life Support guidelines. The authors used these numbers to determine the maximum normal SI for 3 age groups, and then conducted a retrospective review of 543 children aged 4 to 16 years who had been admitted between January 2007 and June 2013 to 2 Colorado trauma centers following blunt trauma and with injury severity scores > 15.

An elevated SI was present in 49% of the children, while an elevated SIPA was present in only An elevated SI was present in 49% of the children, while an elevated SIPA was present in only 27.6% of the children, all of whom had the same adverse outcomes that were identified by using the SI. The SIPA demonstrated improved discrimination of severe injury compared to the SI in the following categories:

- Injury severity score > 30: 37% versus 26%
- Blood transfusion within first 24 hours: 27% versus 20%
- Grade III liver/spleen laceration requiring blood transfusion: 41% versus 26%
- Inhospital mortality: 11% versus 7%

The authors concluded that the SIPA misses fewer children with severe injury while also minimizing overtriage.

A multicenter prospective observational study of 386 patients aged 4 to 16 years (Linnaus 2017) validated the original study with level II-quality evidence.

In 2017, Nordin, Coleman, and Shi, et al, developed SIPA cutoff values for patients aged 1 to 3 years and found the SIPA to be a significantly better predictor than the SI of transfusion needs, injury severity, intensive care unit admission, ventilator use, and mortality following blunt and penetrating trauma.

The authors of the original SIPA study conducted a follow-up study (Acker 2017) and found the SIPA to be superior to age-adjusted hypotension in identifying injured children who required trauma team activation. The criteria used as indicators included early blood transfusion, endotracheal intubation, and emergency operation.

A comparison of the accuracy of the SIPA, SI, and the revised trauma score for predicting outcomes in pediatric trauma patients was presented at the 2017 annual meeting of the Pediatric Trauma Society; the presenters found that the SIPA outperformed the SI and compared favorably to the revised trauma score (Nordin, Shi, Wheeler 2017).

Use the Calculator Now

Click here to access the SIPA on MDCalc.

Calculator Creator

Shannon N. Acker, MD
Click here to read more about Dr. Acker.

References

Original/Primary Reference

- Acker SN, Ross JT, Partrick DA, et al. Pediatric specific shock index accurately identifies severely injured children. *J Pediatr Surg.* 2015;50(2):331-334.
  DOI: https://doi.org/10.1016/j.jpedsurg.2014.08.009

Validation Reference

- Linnaus ME, Notrica DM, Langlais CS, et al. Prospective validation of the shock index pediatric-adjusted (SIPA) in blunt liver and spleen trauma: An ATOMAC+ study. *J Pediatr Surg.* 2017;52(2):340-344.
  DOI: https://doi.org/10.1016/j.jpedsurg.2016.09.060

Other References

- Vandewalle RJ, Peceny JK, Dolejs SC, et al. Trends in pediatric adjusted shock index predict morbidity and mortality in children with severe blunt injuries. *J Pediatr Surg.* 2018;53(2):362-366.
  DOI: https://doi.org/10.1016/j.jpedsurg.2017.10.045
- Qazi K, Wright MS, Kippes C. Stable pediatric blunt trauma patients: is trauma team activation always necessary? *J Trauma.* 1998;45(3):562-564.
  DOI: https://doi.org/10.1097/00005373-199809000-00025
- Wang MY, Kim KA, Griffith PM, et al. Injuries from falls in the pediatric population: an analysis of 729 cases. *J Pediatr Surg.* 2001;36(10):1528-1534.
  DOI: https://doi.org/10.1053/jpsu.2001.27037
- Rousseaux J, Grandbastien B, Dorkenoo A et al. Prognostic value of shock index in children with septic shock. *Pediatr Emerg Care.* 2013;29(10):1055-1059.
  DOI: https://doi.org/10.1097/PEC.0b013e3182a5c99c
- Yasaka Y, Khemani RG, Markovitz BP. Is shock index associated with outcome in children with sepsis/septic shock? *Pediatr Crit Care Med.* 2013;14(8):e372-e379.
  DOI: https://doi.org/10.1097/PCC.0b013e3182975eee
- Nordin A, Coleman A, Shi J, et al. Validation of the age-adjusted shock index using pediatric trauma quality improvement program data. *J Pediatr Surg.* 2017;53(1):130-135.
  DOI: https://doi.org/10.1016/j.jpedsurg.2017.10.023

- Acker SN, Bredbeck B, Partrick DA, et al. Shock index, pediatric age-adjusted (SIPA) is more accurate than age-adjusted hypotension for trauma team activation. *Surgery*. 2017;161(3):803-807.
  DOI: https://doi.org/10.1016/j.surg.2016.08.050
- Nordin A, Shi J, Wheeler K. A comparison of trauma scoring systems using pediatric TQIP data. Paper presented at: 4th Annual Meeting of the Pediatric Trauma Society, November 3, 2017; Charleston, SC.
  http://pediatrictraumasociety.org/meeting/abstracts/2017/8.cgi

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