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The Prognostic Value of the Modified Glasgow Coma Scale in Head Trauma in Dogs

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A clinical coma scale modified from the Glasgow Coma Scale used for humans has been suggested as a useful predictor of outcome in the head trauma patient. The objective of this study was to correlate the modified Glasgow Coma Scale (MGCS) score of dogs with head trauma with their probability of survival. Thirty-eight dogs with head trauma were selected and retrospectively evaluated. The information retrieved from the medical record of each dog included signalment, body weight, cause of head trauma, MGCS, presence of concurrent neck pain, and outcome (dead or alive) after 48 hours. Logistic regression was used to model survival in the 1st 48 hours as a function of MGCS, gender, weight, and calvarial fractures. The MGCS ranged from 5 to 18. Seven dogs died within 48 hours of the head trauma. The MGCS could predict the probability of survival in the 1st 48 hrs after head trauma with 50% probability in a patient with a score of 8. Gender, weight, and presence of skull fractures did not predict survival. In conclusion, the MGCS is a useful index for prediction of outcome in dogs with head trauma.

Key words: Oculocephalic reflex; Skull fracture; Traumatic brain injury.

Severe head trauma is associated with high mortality in human beings and animals.[1,2] The appropriate therapy for head trauma patients remains controversial in veterinary medicine because of the lack of retrospective studies on the treatment of dogs and cats with head trauma. Treatment of affected animals must be immediate if the animal is to recover to a level that is both functional and acceptable to the owner. There is much hope for improvement in the early care of these patients and their functional outcome through the use of evidence-based guidelines.

In humans, traumatic brain injury is graded as mild, moderate, or severe on the basis of the level of consciousness or the Glasgow Coma Scale (GCS).[2] Mild traumatic brain injury in humans usually is due to a concussion, and full neurological recovery occurs. In moderate traumatic brain injury, the patient is lethargic or stuporous, and in severe injury, the patient is comatose. Patients with severe traumatic brain injury have a high risk of hypotension, hypoxemia, and brain swelling.[2] If these sequelae are not prevented or treated properly, they can exacerbate brain damage and increase the risk of death.[2] The clinical point at which to initiate therapy for a head trauma patient in veterinary medicine, the extent of appropriate therapy, and the length of time that such treatment is necessary are poorly documented. The effectiveness of specific treatment and the prognosis for any given animal always will be difficult to assess because of the multifactorial nature of head trauma.

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A modification of the GCS used in humans has been proposed by Shores[3] for use in veterinary medicine. This scoring system enables grading of the initial neurological status and serial monitoring of the patient. Such a system may facilitate assessment of prognosis, which is crucial information for both the veterinarian and the owner.[3] The correlation between this scoring system and the prognosis in dogs with head trauma has not been previously investigated.

In the present study, we reviewed dogs with head trauma over a 9-year period at the University of Georgia Veterinary Teaching Hospital in an effort to correlate the GCS of these patients, upon admission, to their survival over a 48-hour period.

Materials and Methods

Patient Selection

Criteria for inclusion of animals in this study were as follows: (i) dogs admitted to the Intensive Care Unit at the University of Georgia, College of Veterinary Medicine (1990–1999), after acute head trauma were identified from the medical records by means of a selection of key words, including: head trauma or injury, brain trauma or injury, cranio-cerebral trauma or injury, ''hit by car,'' or coma upon presentation; (ii) a neurological examination documented in the medical record, which could be interpreted sufficiently to provide a GCS and performed at the time of admission; each dog was required to have 48 hours follow-up and skull radiographs; and (iii) firm evidence that head trauma had occurred based on any of the following: skull radiographs, computed tomography, coma, stupor, or cranial nerve signs.

Clinical Evaluation

Information retrieved from the medical record of each dog included signalment, body weight, cause of head trauma, presence of concurrent neck pain, and outcome (dead or alive) after 48 hours. If outcome was influenced by financial or emotional concerns of the owner, dogs were removed from analysis to avoid censoring the study. Dogs also were removed from the study if death was due to severe systemic injuries such as splenic laceration or major vessel rupture.

By means of the neurological examinations that had been documented in the records, a modified Glasgow Coma Scale (MGCS) score was assigned to each dog based on the scoring system proposed by Shores[3] (Table 1). A score category also was assigned to each dog based on the above system, which is thought to have prognostic value

Table 1. Modified Glasgow Coma Scale.

	Score
Motor activity	
Normal gait, normal spinal reflexes	6
Hemiparesis, tetraparesis, or decerebrate activity	5
Recumbent, intermittent extensor rigidity	4
Recumbent, constant extensor rigidity	3
Recumbent, constant extensor rigidity with opisthotonus	2
Recumbent, hypotonia of muscles, depressed or absent spinal reflexes	1
Brain stem reflexes	
Normal pupillary light reflexes and oculocephalic reflexes	6
Slow pupillary light reflexes and normal to reduced oculocephalic reflexes	5
Bilateral unresponsive miosis with normal to reduced oculocephalic reflexes	4
Pinpoint pupils with reduced to absent oculocephalic reflexes	3
Unilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes	2
Bilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes	1
Level of consciousness	
Occasional periods of alertness and responsive to environment	6
Depression or delirium, capable of responding but response may be inappropriate	5
Semicomatose, responsive to visual stimuli	4
Semicomatose, responsive to auditory stimuli	3
Semicomatose, responsive only to repeated noxious stimuli	2
Comatose, unresponsive to repeated noxious stimuli	1

as well as indicate the severity of brain injury (Table 2). The timing used for the scoring of each patient unfortunately could not be standardized because of the retrospective nature of the study. Timing presumably was affected by the availability of the neurologist at the time of patient admission, the speed with which the animal was admitted after trauma, preferences of the admitting clinician, and the urgency of the dog's condition. Scoring was found acceptable if recorded at the time of admission and before medication and supportive care were administered. Scoring was based on evaluation of the level of consciousness, motor activity, and brainstem reflexes. Each of the 3 areas of the neurological examination (ie, consciousness, motor activity, and brainstem reflexes) received a score of 1–6. According to the observations made, the animal can have a total score of 3–18. No provision was made in the scoring system for asymmetrical abnormalities (eg, pupil size). Such abnormalities are common in head trauma patients, and this area of the scoring system may warrant modification. We scored patients with asymmetrical abnormalities with the lower of 2 possible scores.

Sequential scores were not evaluated in this study because of the low number of animals that had repeated examinations recorded completely enough for a score to be accurately ascribed to the patient. The scoring system is a dynamic analytical tool, and repeated scoring would be valuable in a prospective study.

Statistical Analysis

Logistic regression was used to model survival in the 1st 48 hours as a function of MGCS, gender, weight, and calvarial fractures.[a] The forward model selection procedure was used and indicated a significant model containing the actual MGCS (model 1). The test statistic to determine model significance was −2log(likelihood) evaluated to 10.108 with 1 degree of freedom, and it had a *P* value of .0007. Model 1 was compared to an alternative model containing only the category of the MGCS (model 2).[4] The respective test statistic and degrees of freedom were 6.737 and 1, which resulted in a *P* value of .0094. This finding suggested that model 1 was a better fit than model 2. The probability of survival with model 1 was calculated with the following equation: probability of survival = $\exp\{-2.6962 + .3469(SCR1)\}/[1 + \exp\{-2.6962 + .3429(SCR1)\}]$ where SCR1 is the MGCS score assigned to the patient.

Table 2. Modified Glasgow Coma Scale score category and suggested prognosis.

Score Category	Actual MGCS score	Suggested Prognosis
I	3–8	Grave
II	9–14	Guarded
III	15–18	Good

MGCS, Modified Glasgow Coma Scale.

Results

Seventy-six dogs were retrieved from the medical records based on the key word search, but 19 dogs were excluded because a GCS score could not be assigned on the basis of findings in the medical records. Another 15 dogs were removed, based on weak evidence that head trauma had been experienced by the patient. Four dogs were removed because of euthanasia within 48 hours at the owners' request. Thirty-eight dogs fulfilled the necessary criteria. No specific breeds or ages were overrepresented. There were 18 males, 5 neutered males, 10 females, and 5 spayed females in the study. Head trauma was vehicle related in 25 dogs (65.8%), associated with a dog fight in 9 cases (23.7%), and gunshot related in 2 (5.3%) dogs; 1 dog (2.6%) was kicked by a cow, and 1 dog (2.6%) fell down a flight of stairs. Only 4 dogs (10.5%) had concurrent neck pain on examination, but no evidence of cervical vertebral trauma was identified on radiographs of the neck. Fourteen dogs (36.8%) had fractures detected on radiographs of the skull. The MGCS ranged from 5 to 18. Seven dogs died, presumably because of the severity of the injury, within 48 hours of the head trauma.

MGCS predicted the probability of survival in the 1st 48 hours after head trauma in an almost linear fashion with a 50% probability of survival in a patient with a score of 8 (Fig 1). The MGCS score category (I-III) was not found to predict patient survival as linearly as the actual score assigned to the patient. Gender, weight, age, and presence of skull fractures did not predict survival.

Discussion

In this study, MGCS correlated with the probability of survival in the 1st 48 hours after head trauma in dogs. The MGCS was 1st proposed by Shores in 1983 as a means of objectively evaluating the neurological status of dogs after head trauma.[3] The score of the patient at any given time may be an indication of the severity of the underlying brain

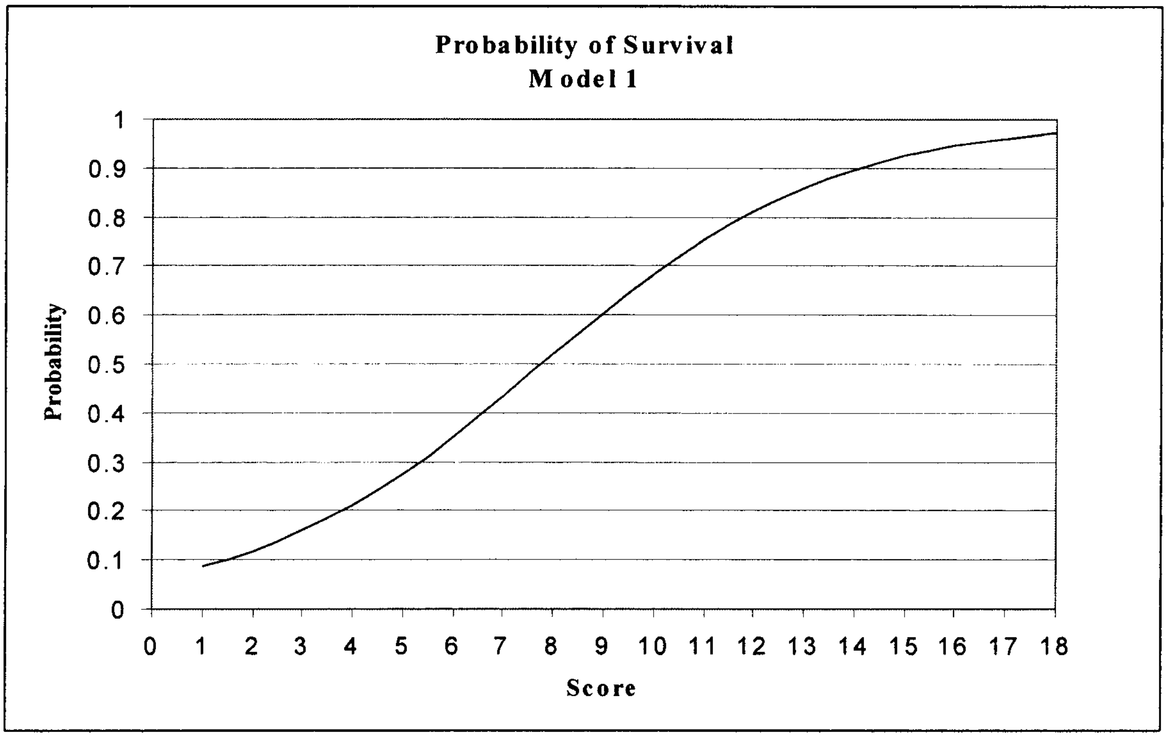

Fig 1. Graph of the probability of survival of a head trauma patient as it relates to the modified Glasgow Coma Scale score assigned to the patient upon admission.

injury, progression of the injury, and beneficial therapeutic effects. The proposal that the MGCS may be useful in predicting an individual patient's prognosis has not been substantiated to the authors' knowledge.

Each of the 3 categories of the examination (ie, level of consciousness, motor activity, and brainstem reflexes) is assigned a score from 1 to 6 (Table 1). The level of consciousness provides information about the functional capabilities of the cerebral cortex and the ascending reticular activating system (ARAS) in the brainstem.[3] Levels of consciousness range from normal, depressed, or delirious to stuporous or comatose. Patients presenting in a state of coma generally have bilateral or global cerebral abnormalities or severe brainstem injury and have a guarded prognosis.[5,6]

Motor activity may be affected by the animal's level of consciousness. Decerebrate rigidity, occasionally seen in animals recumbent because of craniocerebral trauma, can provide further information about the severity of the brain injury.[3] Opisthotonos with hyperextension of all 4 limbs is suggestive of decerebrate rigidity, whereas variable flexion and extension of the hind limbs is seen in rigidity with cerebellar injury.[6,7] In head trauma without spinal involvement, segmental spinal reflexes are normal to exaggerated, but postural reactions may be diminished.

Neuro-ophthalmologic examination is the basis of the brainstem reflexes category. Pupils that respond appropriately to light, even if miotic, indicate adequate function of the rostral brainstem, optic chiasm, optic nerves, and retinae. In the absence of concurrent ocular trauma, miosis may indicate a diencephalic lesion, particularly in the hypothalamus, as this area represents the origin of the sympathetic pathway.[3,6,7] Pupils that are initially miotic and then become mydriatic are indicative of a progressive brainstem lesion, whereas bilateral mydriasis with no response to light usually is indicative of irreversible midbrain damage, herniation of the cerebellum through the foramen magnum, or both.[6] Unilateral mydriasis may indicate unilateral cerebellar herniation or brainstem hemorrhage.[6,8] Oculocephalic reflexes (ie, physiologic nystagmus) also may be impaired with brainstem lesions as a result of either involvement of cranial nerve nuclei that innervate the extraocular muscles or the interconnecting ascending medial longitudinal fasciculus.

In humans, the GCS score is linearly related to poor outcome (eg, death, vegetative state, and severe neurological disability) if it is in the range of 3–9 within the 1st 24 hours.[9–12] However, such retrospective prediction models may not be as useful as they seem initially.[13] For example, treatment factors rarely are constant, and this study is no different in that respect. Coupled with the fact that traumatic brain injury has heterogenous pathology, this study should be interpreted with caution. Until results of a prospective study are available, the information provided by this study may be of some value. These results are valid only over the 1st 48 hours of hospitalization and do not take into account the possibility of death after this time. The decision to evaluate patients over this time period was made because of reliance on the medical records for data. A long-term outcome study was not pursued because of limited follow-up information. The outcome measured in this study was life or death. Therefore, the study does not take into account the functional capacity of the dog at the end of this time period. This type of outcome would be very difficult to quantify statistically in veterinary medicine because often it is based on subjective parameters. The functional outcome of the patient, however, may be more important to the owner than the dog's survival.

Dogs with systemic abnormalities (eg, major vessel rupture) were excluded so as to evaluate dogs that had solely neurological complications of trauma. This approach is artificial because traumatic injuries are rarely so specific in their distribution. Systemic hypoxemia and hypotension occur commonly in humans with head trauma and markedly increase the risk of secondary brain injury and the likelihood of a poor outcome.[14–16] The prevalence of these abnormalities has not been evaluated in veterinary medicine, but the authors' clinical experience suggests they also are common in animals. Consideration then should be given to the possibility of concurrent chest injury, hypoventilation, ventilation-perfusion mismatching, and neurogenic pulmonary edema.[17] The systemic or mean arterial blood pressure (MABP) has been suggested as a valuable monitoring parameter for the management of head-injured dogs because it is closely related to cerebral blood flow and brain perfusion.[5] As MABP decreases to <50 mmHg, vasodilatation ensues, and cerebral blood flow decreases and becomes dependent on MABP.[13]

Head trauma may result from many different events, including motor vehicle accidents, bites, kicks, or penetrating injuries such as gunshot wounds.[8] In humans, in both developed and underdeveloped countries, motor vehicles are the major cause of head trauma, particularly in young people.[18] Falls are the leading cause of death and disability from traumatic brain injury in people older than 65 years.[2] The most frequent cause of head trauma noted in small animals is motor vehicle trauma.[3,19] Although we did not find a dramatic interaction between age and head trauma, 66% of the dogs died due to motor vehicle trauma. Twenty-four percent of the dogs had been injured by dog fights, and other etiologies included gunshot injuries, falls, and kicks.

Approximately 37% of the dogs in this study had evidence of calvarial fractures on radiographic examination. No relationship was found between the presence of fractures and the patient's outcome. This does not imply that specific surgical therapy for a patient with skull fractures should not be employed, because this question was not addressed in this study. Radiographic examination of the skull may provide useful information in head-injured animals, especially if there is the suspicion of fractures or penetrating injuries. Computed tomography (CT) or magnetic resonance imaging (MRI) are more valuable if available.[7,20]

In summary, we correlated the outcome of dogs with head trauma after 48 hours with their MGCS score upon admission. Such indicators of prognosis are useful and can be measured routinely and reliably. These scales may yield more specific predictive information in the future, when treatment is standardized and injury is categorized into specific pathological entities.

Footnote

[a] Logistic Regression (statistical procedure): SAS version 6.12, SAS Institute, Inc, Cary, NC. The procedure used within the software was PROC LOGISTIC.

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References

1. Dewey CW. Emergency management of the head trauma patient. In: Thomas WB, ed. Veterinary Clinics of North America: Small Animal Practice. Philadelphia, PA: WB Saunders; 2000:207–225.
2. Ghajar J. Traumatic brain injury. Lancet 2000;356:923–929.
3. Shores A. Craniocerebral trauma. In: Kirk RW, ed. Current Veterinary Therapy X. Philadelphia, PA: WB Saunders; 1983:847–854.
4. Agresti A. Categorical Data Analysis. New York, NY: J Wiley; 1990.
5. Gruen P, Liu C. Current trends in the management of head injury. Emerg Med Clin North Am 1998;16:63–83.
6. Johnson JA, Murtaugh RJ. Craniocerebral trauma. In: Bonagura JD, ed. Kirk's Current Veterinary Therapy XIII. Philadelphia, PA: WB Saunders; 2000:178–186.
7. Fenner WR. Diseases of the brain. In: Ettinger SJ, Feldman EC, eds. Textbook of Veterinary Internal Medicine, Diseases of the Dog and Cat, 4th ed. Philadelphia, PA: WB Saunders; 1995:578–629.
8. Hopkins AL. Head trauma. Vet Clin North Am Small Anim Pract 1996;26:875–891.
9. Marshall LF, Gautille T, Klauber MR, et al. The outcome of severe closed head injury. J Neurosurg 1991;75:S28–S36.
10. Ghajar J, Hariri RJ, Narayan RK. Survey of critical care management of comatose, head injured patients in the United States. Crit Care Med 1995;23:560–567.
11. Maas AI, Dearden M, Teasdale GM, et al. EBIC—Guidelines for management of severe head injury in adults. Acta Neurochir 1997; 139:286–294.
12. Brain Trauma Task Force. Management and prognosis of severe traumatic brain injury. J Neurotrauma 2000;17:557–627.
13. Choi SC, Ward JD, Becker DP. Chart for outcome prediction in severe head injury. J Neurosurg 1983;59:294–297.
14. Chestnut RM, Marshall LF, Klauber MR, et al. The role of secondary brain injury in determining outcome from severe head injury. J Trauma 1993;34:216–222.
15. Fearnside MR, Cook RJ, McDougall P, et al. The Westmead Head Injury Project outcome in severe head injury; a comparative analysis of pre-hospital, clinical and CT variables. Br J Neurosurg 1993;7:267–279.
16. Pietropaoli JA, Rogers FB, Shackford SR, et al. The deleterious effects of intraoperative hypotension on outcome in patients with severe head injuries. J Trauma 1992;33:403–407.
17. Kaufmann HH, Timberlake G, Voelker J, et al. Medical complications of head injury. Med Clin North Am 1993;77:43–60.
18. Murray CJL, Lopez AD. Global mortality, disability and the contribution of risk factors: Global Burden of Disease Study. Lancet 1997;349:1436–1442.
19. Kolata RJ, Krant NH, Johnston OE. Patterns of trauma in urban dogs and cats: A study of 1000 cases. J Am Vet Med Assoc 1974; 164:499–502.
20. Zink BJ. Traumatic brain injury. Emerg Med Clin North Am 1996;14:115–150.