health technology assessment

REPORT

CT SCAN FOR HEAD INJURY WITH GCS LESS THAN 5

HEALTH TECHNOLOGY ASSESSMENT UNIT
MEDICAL DEVELOPMENT DIVISION
MINISTRY OF HEALTH MALAYSIA
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EXECUTIVE SUMMARY

1. INTRODUCTION

Head injury is a significant economic, social and medical problem all over the world. For this reason, prognostic factors in head injury are of major importance to all surgeons who treat severely injured patients. Outcome of severe head injury is frequently determined at the time of impact, and surgical and medical treatment is often ineffective. Often patients with traumatic brain injury (TBI) initially presenting to non-tertiary care facilities required interhospital transfer for neurosurgical and intensive care services. Delays in initiating definitive neurosurgical care in regions with long ground travel times are common. Despite the potential seriousness of traumatic brain injury, not all individuals who sustain a severe brain injury will benefits interhospital transfer for specialized care and resources. Relying exclusively upon the severity of the Glasgow Coma Scale as a criteria to identify patients for interhospital transfer for CT scanning and high level of care may not be ideal, as not all severely brain injured patient will benefits form the transfer. In many circumstances, the decision to transfer must balance the costs, risks, prognosis, and resources required for transport with the procedures and treatments that will be provided when he/she arrives at the tertiary care facility. We reason that there is a need to develop clinical decision driven guidelines, using information readily available during the initial emergency department evaluation, to identify those group of severely brain injured patients that are not likely to benefits from the transfer.

2. POLCY QUESTION

In patients with very severe traumatic brain injury with post resuscitation Glasgow Coma Scale less than 5, should interhospital transfer be carried out for the purpose of CT scanning and high level of specialize care?

3. OBJECTIVES

To identify the group of patients with severe traumatic brain injury that will not benefits interhospital transfer for specialized tertiary care resources such as CT scanning.

4. METHODOLGY

An electronic search of various databases was carried out from 1980 to 2005, using specific search terms either singly or in combination. The literature retrieved was reviewed and critically appraised, then tabulated, and the evidence graded according to the modified Catalonian Agency for Health Technology Assessment & Research scale.

5. RESULTS

There is sufficient evidence that Glasgow Coma Scale (GCS) is a good predictor of outcome in adult patients with severe head injury, with especially good correlation between low GCS and mortality. There is insufficient evidence of its suitability for pediatric patients.

With respect to diagnosis, there is sufficient evidence that CT scan is effective in determining the type and location of the brain injuries, except in patients with diffuse axonal injuries. There is also good evidence that CT scans can predict patient outcomes in patients with head injuries either through evidence of traumatic intracranial haemorrhage or overall appearance of the CT scan. In the case of children, the evidence is inconclusive.

There is sufficient evidence that raised intracranial pressure is a predictor of poor outcome in patients with head injury. Evidence is also available that age is a factor in determining mortality, older patients with head injury having a higher mortality rate. With respect to abnormal pupillary reaction, there is sufficient evidence that abnormal eye movements or pupil light reflexes are predictors of poor outcomes in adult patients with severe head injury. Systemic hypotension and hyperglycemia have been shown to be associated with increased morbidity and mortality in patients with severe head injury, the latter in both adults and

children. There is some evidence that low cerebral perfusion pressure is associated with increased morbidity and mortality in both adults and children with severe head injury. There is insufficient evidence on the effects of hypoxia, abnormal motor responses and absence of occulo-cephalic reflex in patients with severe head injury.

6. CONCLUSIONS

There is sufficient evidence that GCS is a good predictor of outcome in adult patients with severe head injury, but not for pediatric patients. There is also good evidence that CT scan is effective in diagnosis of severity of head-injuries in adults, except in the case of children where the evidence is inconclusive. There is sufficient evidence that other parameters like raised intracranial pressure, abnormal pupillary reaction, systemic hypotension and hyperglycemia are associated with increased morbidity and mortality in patients with severe head injury. There is some evidence that low cerebral perfusion pressure is associated with increased morbidity and mortality, while there is insufficient evidence on the effects of hypoxia, abnormal motor responses and absence of occulo-cephalic reflex.

7. RECOMMENDATIONS

Since GCS has been shown to be a good predictor of outcome in adult patients with severe head injury, with good correlation between very low GCS and mortality, it is recommended that patients with severe traumatic brain injury presenting to a non tertiary care facilities should not be urgently transfer for CT scanning if the post resuscitation GCS is less than 5, particularly in the presence of systemic hypotension with or without hypoxia, fixed dilated pupils and absence of eye movements in an elderly patients. This is due to the high probability of dying and surgical and medical treatments are often ineffective. The patients should be continouslly resuscitated and the progress of its vital and neurological parameters be monitored. Transfer for CT scanning and higher level of care can be considered after in hemodynamically stable patients with improving GCS.

TABLE OF CONTENT

1. INTRODUCTION

Head injury is a significant economic, social and medical problem all over the world. It is also a leading cause of death and permanent disability - almost everyone with severe head injury, and as many as two-thirds of those with moderate head injury, will be permanently disabled and will not return to their pre-morbid level of function(Shepard, http://www.emedicine.com, 28/7/05). In the US, of the 500,000 patients with head injury seen in Emergency Departments each year, 20% are admitted, of whom 10% are in coma, around 35% of patients with severe head injury die, and 18% are severely disabled(Robert, 2003; Littlejohns & Bader 2001). Apart from this, head injuries kill and disable more people less than 50 years old than any other type of neurologic damage. The commonest cause of head injury is motor vehicle accidents, accounting for more than 70%. Head injury is also the leading cause of death in males younger than 35 years, and nearly 50% of people who have severe head injury die (http://www.merck.com/mmhe 28/7/05). In Malaysia, road accidents are the most frequent cause of head injury with highest risk in the young population. Associated outcomes include good recovery, possibility of death for the severely injured, which may cause disruption of the lives of their family members (Azian et al, 2001). Other common causes of head injury are fall in the home, physical assaults, and accidents during sports, recreational activities, or at the work place e.g. while operating machinery (http://www.merck.com/mmhe 28/7/05)

Head injury may be described as traumatic brain injury, severe head injury, acute head injury or closed head injury. All these terms are used to describe the effect of an injury caused by a traumatic event on the brain, and a score of 8 or less on the Glasgow coma scale indicates severe head injury (Littlejohns & Bader, 2001). Primary brain injury is defined as the cerebral tissue damage that occurs at the moment of injury, and it cannot be rendered by therapeutic intervention. Secondary brain injury, on the other hand, is the delayed loss of viable brain tissue due to various causes at the moment of injury, the most common being hypoxia and others include hypo-perfusion attributable to shock, or ischaemia attributable to local mass effect (Downward et al, 2000)

In US the direct cost of care patient with traumatic brain injury, excluding patient care, was estimated at more than $25 billion annually. These impacts are even greater when it is considered that most severe head injuries occur in adolescents and young adults (Shepard, http://www.emedicine.com, 28/7/05)

2. POLCY QUESTION

In patients with very severe traumatic brain injury with post resuscitation Glasgow Coma Scale less than 5, should interhospital transfer be carried out for the purpose of CT scanning and high level of specialize care?

3. OBJECTIVES

To identify the group of patients with severe traumatic brain injury that probably will not benefits interhospital transfer for specialized tertiary care resources such as CT scanning.

4. METHODOLOGY

An electronic search using the following databases - PUBMED; Journal@ovid; Cochrane database of systematic reviews, ACP Journal Club, DARE, Cochrane Controlled Trial Register; CINAHL and Google was carried out from 1980 to 2005, using the following search terms *CT scans, severe head injury, severe brain injury, efficacy, outcome prediction, prognosis, predictor, risk factors, intracranial pressur, Glasgow Coma Scale, eye movement, motor reflex, traumatic head injury,* and *traumatic brain injury,* either singly or in combination

The literature retrieved was reviewed and critically appraised, then tabulated, and the evidence graded according to the Modified CAHTAR scale.

5. RESULTS AND DISCUSSION

5.1 Glasgow Coma Scale

The initial Glasgow Coma Scale(GCS), score has been found to be closely related to the mortality rate - patients with GCS of, 3 - 4 had a mortality rate of 97% those with GCS 5 - 6 had a rate of 72%, while patients with GCS 7 - 8 had rates of 36% (Aguemon et al, 2005). Another study in Singapore revealed that an admission GCS of 8 or less amongst elderly patients with moderate and severe traumatic brain injury, if could significantly predict mortality rate (Gan, Lim & Ng, 2004). It was also found a low GCS score and advanced age were highly correlated risk factors that when combined, were independently associated with mortality (Schreiber et al, 2002). In Kenyatta National Hospital, it was found that those patients with the admission GCS of 3 - 4 had a mortality rate of 88% compared with those with GCS 5 - 6 who had a mortality of 60%, while those with admission GCS of 7 - 8 had a mortality of 52% (Mwang'ombe & Kiboi, 2001). A study also found that within the population of very severely head injury patients who have GCS score of 3 - 5, a simple combination of age and admission GCS score appears to predict accurately non-functional outcome in almost one third of patients (Quigley et al, 1997). It was also found that that 82% of patients with GCS 5 or less correlated with a very poor final outcome (Lobato et al, 1988). A study in Malaysia on the outcome prediction in early management of severe head injury found that for a subset of patients aged more than 20 with GCS 3 - 5 and partial or complete obliteration of peri-mesencephalic cistern (PMC), 89.3% correct predictions were made for a poor outcome while those less than 20 years with GCS 6 - 8 and patent PMC had 71.4 % correct prediction of good outcome (Selladurai et al, 1992). Another study found that the state of the cistern was more important for those with higher GCS scores (6 - 8) than for those with lower scores (3 - 5). Patient with GCS of 6-8 with cisterns absent or not visualized suffered nearly a fourfold additional risk of poor outcome compared to those with normal cisterns (Tautant et al, 1984). It was also found that there was no significant difference between mortality rate in those predicted to have poor outcome and the very best outcome in the group of patients with GCS 3 - 4 and those with GCS 5 - 8 (Abraszko et al, 1997).

In the paediatric population, a study found that GCS correctly predicted unfavorable outcome with a sensitivity of 79% and specificity of 65% (Pillai et al, 2001). On the other hand, another study found that many patients with GCS 5 or less can survive with good function (Thakker et al, 1997). GCS has also been found to be not reliable in predicting an unfavorable outcome in another study (Riffel et al, 1989).

5.2 Therapeutic Efficacy of CT Scan

5.2.1 Diagnosis

There was no RCT found on the efficacy of CT scan in the diagnosis of severe head injury. However, a review showed that CT scan was clearly efficacious in determining location, volume, extent and multiplicity of brain haematoma (Lannoo et al, 2000). Several prospective studies have shown that there is a co-relation between the grades or severity of head-injuries, with types and extent of severity of the abnormalities, and CT scan findings (Servadei et al, 2002; Hirsch et al, 2002; Lannoo et al, 2000; Eisenberg et al, 1990; Kobayashi et al, 1988; Hennes et al, 1988; Turazzi et al, 1987; Toutant et al, 1984; Lobato et al, 1983, Ono et al, 1983; Bruce & Schut, 1980). However**,** it has been shown that the initial CT scan findings of patients who sustained diffuse axonal injuries may not co-relate with clinically severe head injury (Hirsch et al, 2002; Nau et al, 1979; Merino-deVillasante & Taveras, 1976).

5.2.2 Outcome prediction

CT scan findings were found to be independent prognostic variables in the prediction of patient outcome, and may help identify patients with higher morbidity or possible mortality risks (Mattioli et al, 2003; Wardlaw, Easton & Statham, 2002; Servadei et al, 2002; Lannoo et al, 2000; Fearnside et al, 1993; Selladurai et al, 1992; Lipper et al, 1985 Kishore et al, 1981). It was also found that the most important CT scan indicators for predicting morbidity or mortality from head injuries were evidence of traumatic intracranial haemorrhage (Mattioli et al, 2003; Servadei et al, 2002; Wardlaw, Easton & Statham, 2002; Azian et al, 2001; Kishore et al, 1981) as well as the grading of the overall appearance of CT scan (Selladurai et al, 1992; Lipper et al, 1985; Toutant et al, 1984; Kishore et al, 1981).

A retrospective study in a paediatric population, found that the initial cranial CT (CCT) was important for further therapy, especially for children in need of surgical treatment. In the other cases, there was no direct impact of CCT findings on treatment procedures in the paediatric intensive care unit. The initial CCT was related to the prognosis, it being poor even if there were only minimal changes such as focal oedema or isolated ventricular bleeding (Hirsch et al, 2002). CT scan has also proven to be invaluable in the management of severe paediatric head traumas, and the most frequent findings are those of sub-arachnoid hemorrhage and diffuse swelling (Bruce & Schut 1980).

Another study, however, found that an early CT scan or a single CT scan did not have any prognostic significance, except if traumatic sub-arachnoid haemorrhage was present, being an independent predictor of poor outcome (Pillai et al, 2001).

.5.3 Other Parameters

5.3.1 Raised Intracranial pressure

Raised intracranial pressure (intracranial hypertension) was found to be the only independent risk factor for mortality that can be readily treated during the initial management of patient with severe head injury (Schreiber et al, 2002). Studies also found that intracranial hypertension was definitely an ominous predictor of outcome of patients with severe head injury, if it was very high the risk of mortality is increased, while an uncontrollable increase in intracranial pressure was often fatal, despite aggressive therapy, contributing to about half of all deaths in severe head

injury patients (Lobato et al, 2005; Thomas et al, 2000; Juul et al, 2000; Celli, Fruin & Cervoni, 1997; Fearnside et al, 1993; Miller et al, 1981).

However, a case study found no difference between patients with good outcome (GCS 4-5) or those with poor outcome (GCS 1-3) irrespective of the mean or peak intracranial pressure (ICP). Further, it was found that younger patients particularly those with GCS >5 have the potential for recovery despite prolonged (> 96 hours) intracranial hypertension (Resnick, Marion & Carlier, 1997).

5.3.2 Age

Increasing age was found to result in a higher mortality rate in patients with severe head injury (Yamamto, Mori & Maeda, 2002; Schreiber et al, 2002; Mwang'ombe & Kiboi, 2001; Thomas et al, 2000; Celli, Fruin & Cervoni, 1997; Ono et al, 1993; Fearnside et al, 1993; Selladurai et al 1992; Miller et al, 1981). A comparative study of paediatric population against adults focusing on the relationship of admission GCS score, motor score, blood pressure, papillary reactivity, the presence of associated injuries, and the presence of sub-dural or epidural haematoma, with post traumatic mortality found a significantly lower mortality rate in paediatric patients (Luerssen, Klauber & Marshall, 1988)

5.3.3 Abnormal pupillary reaction

Impaired or absent eye movements or pupil light reflexes, bilateral dilated pupils or bilaterally constricted pupils at admission were predictive factors for poor outcomes in adult patients with severe head injury in (Scheiber et al, 2002; Prasad et al, 2002; Matsumae et al, 2001; Mwang'ombe & Kiboi, 2001; Fearnside et al, 1993; Selladurai et al 1992; Miller et al, 1981), as well as in children (Prasad et al, 2003; Pfennigner & Santi, 2002; Pillai et al, 2001). However, it has been found that even patients with normal pupillary reactions to light at time of admission have also died (Mwang'ombe & Kiboi, 2001)

5.3.4 Hypotension and hypoxia

Systemic hypotension has been found to be associated with death in patients with severe head injury (Schreiber et al, 2002; Abraszko et al, 1997; Fearnside et al, 1993). Hypoxia and hypotension were independently associated with significant increases in morbidity and mortality in patient with severe head injury (Andrews et al, 2003; Jeemitsky et al, 2003; Thomas et al, 2000; Stocchetti, Furlan & Volta, 1996; Wald, Shackford & Fenwick, 1993; Chesnut et al, 1993 a; b; Lobato et al, 1988; Kohi et al, 1984; Miller et al, 1981). A study in Kenya on the effect of hypotension found that 85% of patients with systolic BP less than 90 mm Hg on admission died, while 60% of those with systolic BP greater than 120 mmHg died (Mwang'ombe & Kiboi, 2001). It has also been found that patients with moderate to severe head injury with systolic blood pressure less than 90mmHg on admission had a 100 % mortality rate (Nirula & Gentilello; 2004). However, a prospective cohort study found hypotension, but not hypoxia, occurring in the initial phase of resuscitation, was significantly associated with increased mortality following brain injury, even when the episode were relatively short (Manley et al, 2001).

Early aggressive resuscitation to prevent hypotension and hypoxia has been found to improve patient outcomes in severe head injury patients (Ng et al, 1998)

5.3.5 Abnormal motor responses

Prospective studies show that abnormal motor responses was a predictive factor contributing to mortality in patients with severe head injury (Fearnside et al, 1993; Miller et al, 1981)

5.3.6 Hyperglycemia

Early hyperglycemia was associated with poor outcomes for patients with severe traumatic head injury (Jeremitsky et al, 2005). It has also been shown significantly higher admission serum glucose values, equal to or more than 300 mg/dL, are associated with increased mortality (Cochran et al, 2003). Patients with a significantly higher glucose level (more than 200mg/dl) were found to have an unfavorable outcome (Rovlias & Kotsou, 2000). Another study found that 90% of patients with blood glucose level of 171.4mg/100ml at admission died within the first month (Yang, Zhang & Wang, 1995).

In children with severe head injury, those with significant higher glucose concentrations (7.1 mmol/L) were found to have a poor outcome (Paret et al. 1999). Hyperglycaemia, and especially its persistence over time, appears to be an important negative prognostic factor in children with head injury (Chiaretti et al, 1998).

An observational study showed that hyperglycemia and low mean arterial pressure (MAP) and were associated with increasing mortality in patients with severe head injury, although further studies are needed on the combined effect of hyperglycemia and hypotension on mortality after head injury (Walia & Sutcliffe, 2002).

5.3.7 Low cerebral perfusion pressure

A cerebral perfusion pressure (CPP) less than 60mmHg was found to be a significant predictor of favorable outcome (Elf et al, 2005, Juul et al, 2000), with low CPP being the best predictor of death (Andrews et al, 2003). Patients with CPP < 50 mmHg were found to have higher mortality rate (69%) (Thomas et al, 2000)

In the paediatric population, a study showed that inability to maintain a cerebral perfusion pressure of less than or equal to 50 mm Hg on the first paediatric critical care unit day was the strongest factor associated with mortality (Hackbarth et al, 2002). Low mean CPP was found to be lethal with no survived in children with severe head injury with mean CPP < than 40 mmHg (Downard et al, 2000).

5.3.8 Absence of occulocephalic reflex

The absence of oculocephalic reflex has been found to be an independent predictor for poor outcome in children with severe head injury (Pillai et al, 2001).

6. CONCLUSIONS

6.1. Glasgow Coma Scale

There is sufficient evidence that GCS is a good predictor of outcome in adult patients with severe head injury, with especially good correlation between low GCS and poor outcome. There is insufficient evidence of its suitability for pediatric patients.

6.2. Therapeutic Efficacy of CT Scan

With respect to diagnosis, there is sufficient evidence that CT scan is effective in determining severity of head-injuries in adults, except in patients with diffuse axonal injuries. There is also good evidence that CT scans can predict patient outcomes morbidity or mortality in patients with head injuries either through evidence of traumatic intracranial haemorrhage or overall appearance of the CT scan. In the case of children, the evidence is inconclusive.

6.3. Other Parameters

There is sufficient evidence that raised intracranial pressure is a predictor of poor outcome in patients with head injury. Evidence is also available that age is a factor in determining mortality, older patients with head injury having a higher mortality rate. With respect to abnormal pupillary reaction, there is sufficient evidence that abnormal eye movements or pupil light reflexes are predictors of poor outcomes in adult patients with severe head injury. Systemic hypotension and hyperglycemia have been shown to be associated with increased morbidity and mortality in patients with severe head injury, the latter in both adults and children. There is some evidence that low cerebral perfusion pressure is associated with increased morbidity and mortality in both adults and children with severe head injury. There is insufficient evidence on the effects of hypoxia, abnormal motor responses and absence of occulo-cephalic reflex in patients with severe head injury.

7. RECOMMENDATIONS

There is sufficient evidence to show that GCS is a good predictor of outcome in adult patients with severe traumatic brain injury, with good correlation between very low GCS and mortality. Its reliability and sensitivity increases with the presence of other clinical parameters like systemic hypotension with or without hypoxia, fixed dilated pupils, absence of eye movements and elderly patient

It is recommended that patients with severe traumatic brain injury presenting to a non tertiary care facilities should not be transfer for CT scanning if the post resuscitation GCS is less than 5, particularly so in the presence of systemic hypotension with or without hypoxia, fixed dilated pupils and absence of eye movements in an elderly patients. This is due to the high probability of dying and surgical and medical treatments are often ineffective. The patients should instead receive continuous resuscitation and the progress of its vital and neurological parameters be monitored. Patients with an improving GCS and stable vital parameters may be reconsidered for CT scan and a higher level of neurosurgical management following consultation with a tertiary neurosurgcical center. This recommendation is suited for emergency departmnet without CT scan facility.

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EVIDENCE TABLE

Glasgow coma scale

No.	Author, title, Journal, Year, Vol, Pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
1	Selladurai BM, Jayakumar R, Tan YY, Low HC (1992) Outcome prediction in early management of severe head injury: an experience in Malaysia *J Neurosurg*, 6(6), pp 549 -57	N= 109 patients	For the subset of patients aged < 20 years, with GCS 6-8 and patent perimesencephalic cistern (PMC) 71.4 % correct predictions were made for good outcome. For the subset of patient aged > 20 , with GCS 3-5 and partial or complete obliteration	8
2	Mwang'ombe NJ, Kiboi J (2001) Factors influencing the outcome of severe head injury in Kenyatta National Hospital *East Afr Med J*, 78(5), May, pp 238- 41	N= 677 F/up: 4 year	The admission GCS of 3-4 had a mortality of 88% those with GCS 5-6 had a mortality of 60% and those with admission GCS 7-8 had a mortality of 52%	7
3	Quigley MR, Vidovich D, Cantella D, Willberger JE, Maroon JC, Diamond D (1997) Defining the limits of survivorship after very severe head injury *J Trauma*, 42(1), pp 7 – 10	Retrospective review N = 380 patients F/up: 5 years	Within the population of very severely head injury patients (GCS score 3-5), the simple combination of age and admission GCS score appears to predict accurately non functional outcome in almost one third of patients.	8
4	Aguemon AR, Padonou JL, Yevegnon SR, Hounkpe PC, Madougou S, Djagnikpo AK (2005) Intensive care management of patients with severe head traumatism in Brain from 1998 to 2002 *Ann Fr Anesth Reanim*, 24(1), pp 36 -9	Retrospective study f/up: 4 years	Mortality rate was closely related to the initial Glasgow coma scale score (GCS 3-4 =97%; GCS 5-6 + 72%, GCS 7-8= 36%. Overall mortality rate was 70%	7

No.	Author, title, Journal, Year, Vol, Pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
5	Gan BK, Lim JH, Ng IH (2004) Outcome of moderate and severe traumatic brain injury amongst the elderly in Singapore *Ann Acad Med Singapore,* 33 (1), Jan, pp 63 -77	Cohort N= 324 patients	The GCS of < or = 8 on admission was significantly in predicting mortality in the elderly. In the elderly group, the female gender had a higher mortality rate (70.4%) than males (44.7%)	7
6	Schreiber MA, Aoki N, Scott BG, Beck JR (2002) Determinants of mortality in patients with severe blunt head injury *Arch Surg,* 137(3), Mar, pp 285 -90	Validation Cohort study	A low Glasgow coma scale score and advanced aged were found to be highly correlated risk factors that when combined, were independently associated with mortality	8
7	Abraszko R, Zurynski Y, Dorsch N, Mudaliar Y (1997) Evaluation of treatment outcome in patients after extremely severe head injury (GCS 3-4) *Neurol Neurochir Pol,* 31(1), Jan – Feb, pp 103 -12	N= 62 patients with severe head injury	No significant difference between mortality, poor outcome and the very best outcome in the group of patient with GCS 3-4 and those with GCS 5-8	8
8	Lobato RD, Sarabia R, Cordobes F, Rivas JJ, Adrados A, Cabrera A, Gomez P, Madera A, lamas E (1988) Posttraumatic cerebral hemispheric swelling. Analysis of 55 cases studied with computerized tomography *J Neurosurg,* 68(3), mar, pp 417 -23	N= 55 severely head injury patients	The severity of the clinical presentation (82% of patients scored 5 points or less on the Glasgow coma scale correlated with a very poor final outcome	8
9	Pillai S, Praharaj SS, Mohanty A, Kolluri VR (2001) Prognostic factors in children with severe diffuse brain injuries *Pediatr Neurosurg,* 34(2), Feb, pp 98 -103	Retrospective study N= 74 patients F/up: 4 years	GCS correctly predicted unfavorable outcome with a sensitivity of 79% and specificity of 65%. A single CT did not have any prognostic significantly	8

No.	Author, title, Journal, Year, Vol, Pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
10	Thakker Jc, splaingard M, Zhu J, Babel K, Bresnahan J, Havencs PL (1997) Survival and function outcome of children requiring endotracheal intubations during therapy for severe brain injury *Crit Care Med,* 25(8), pp 1396 -401	Retrospective study N= 105 patient F/up 5 years	PRISM score add to the power of GCS to predict survival. Many patient with GCS , or = 5 can survive with good function	6
11	Riffel B, Stohr M, Graser W, Trost E, Baumgartner H (1989) Early prognosis in severe cranio-cerebral trauma using the Glasgow coma score and evoked potentials *Anaesthetist,* 38(2), Feb, pp 51 – 8	N= 103 patients	The GCS was not reliable in predicting an unfavorable outcome	8
12	Toutant SM, Klauber MR, marshall LF, Toole BM, Bowers SA, Seelig JM, Varnell JB (1984) Absent or compressed basal cisterns on first CY scan: Ominous predictors of outcome in severe head injury *J Neurosurg,* 61(4), Oct, pp 691 – 4	N= 218 patients	The association between cisterns and outcome was shown to be strong after adjusting for Glasgow coma scale score. The state of the cistern was more important for those with higher GCS scores (6-8) than for those with lower scores (3-5). Patient with GCS of 6-8 with cisterns absent or not visualized suffered nearly a fourfold additional risk of poor outcome. Compared to those with normal cisterns.	9

Efficacy of CT scans in the diagnosis and outcome prediction in severe head injury

No.	Author, title, Journal, Year, vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
1	Servadei F, Murray GD, Teasdale GM, Dearden M, Iannotti F, Lapierre F, Maas AJ, Karimi A, Ohman J, Persson L, Stocchetti N, Trojanowski T, Unterberg A. (2002) Traumatic subarachnoid hemorrhage: demographic and clinical study of 750 patients from the European brain injury consortium survey of head injuries. *Neurosurgery*, 50(2), Feb, pp 261-7; discussion 267-9	N=750	There was a strong, highly statistically significant association between the presence of tSAH based on CT scans and poor outcomes	8
2	Lannoo E, Van Rietvelde F, Colardyn F, Lemmerling M, Vandekerckhove T, Jannes C, De Soete G. (2000) Early predictors of mortality and morbidity after severe closed head injury *J Neurotrauma*, 17(5), May, pp 403-14	N=158. Used a regression model with CT scan as one of the predictors. Logistic regression analyses combined 13 out of 16 predictors into a model with an accuracy of 93%, a sensitivity of 90%, and a specificity of 95%.	Mortality and morbidity of 158 patients with severe head injury were studied in relation to age, and early (24-h) clinical and computed tomography data CT important for predicting mortality but failed to show any significant relationship with morbidity. Mortality rate =51%	8
3	Eisenberg HM, Gary HE Jr, Aldrich EF, Saydjari C, Turner B, Foulkes MA, Jane JA, Marmarou A, Marshall LF, Young HF. (1990) Initial CT findings in 753 patients with severe head injury. A report from the NIH Traumatic Coma Data Bank. *J Neurosurg*,73(5), Nov, pp 688-98	Prospective multicenter Clinical Trial Study N=733	CT findings were related to abnormal intracranial pressure Describes important characteristics of the scans	2

No.	Author, title, Journal, Year, vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
4	Kobayashi S, Nakazawa S, Yokota H, Isayama K, Yano M, Otsuka T.(1988) Traumatic subarachnoid hemorrhage in acute severe head injury *No To Shinkei*,40(12), Dec, pp 1131-5	Retrospective analysis N=414, severe head injury All has CT within 24 hours of injury Aim of study: to describe the CT findings, nature and prognosis of TSAH	In lower GCS scores, there were more frequent TSAH identified	6 Article in Japanese
5	Hennes H, Lee M, Smith D, Sty JR, Losek J. (1988) Clinical predictors of severe head trauma in children *Am J Dis Child*,142(10), oct, pp 1045-7	Prospective analysis N=55	All patients with mild or moderate head trauma had normal CT scans. Severe head trauma, as defined in this study, accurately identified all patients with abnormal CT scan findings.	4 Sample size to be small, according to investigators
6	Turazzi S, Bricolo A, Pasut ML, Formenton A. (1987) Changes produced by CT scanning in the outlook of severe head injury. *Acta Neurochir (Wien)*; 85(3-4), pp87-95	Non-randomised controlled prospective trial with historical control N=1000	On admission, cerebral angiography and CT scanning were equally effective in detecting lesions of surgical import	5
7	Lobato RD, Cordobes F, Rivas JJ, de la Fuente M, Montero A, Barcena A, Perez C, Cabrera A, Lamas E (1983) Outcome from severe head injury related to the type of intracranial lesion. A computerized tomography study. *J Neurosurg*;59(5), Nov, pp 762-74	N=277 severely head-injured patients	CT findings of anatomical patterns have clinical and physiopathological significance, they provide useful prognostic information and facilitate improved therapeutic decision-making in severely head-injured patients.	5

No.	Author, title, Journal, Year, vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
8	Ono J, Yamaura A, Horie T, Makino H, Nakamura T, Isobe K, Shinohara Y, WatanabeY, Ariga N.(1983) [CT scan in severe head injury with special reference to Glasgow coma scale] *No Shinkei Geka* ,11(4), Apr, pp 379-87	N=174 cases with severe head injury were analysed.	CT scan demonstrates the invaluable information about the parenchymal lesions of head injuries	4 In Japanese
9	Kishore PR, Lipper MH, Becker DP, Domingues da Silva AA, Narayan RK. (1981) Significance of CT in head injury: correlation with intracranial pressure. *Am J Roentgeno,*137(4), Oct, pp:829-33	N=150	study reveals that a majority of patients (55%) withhemorrhagic lesions shown by CT suffer from intracranial hypertension and require ICPmonitoring for proper management	4
10	Bruce DA, Schut L. (1980) The value of CAT scanning following pediatric head injury *Clin Pediatr (Phila)*; 19(11), Nov, pp 719-25	not described	CAT scan has proven invaluable in the management of severe pediatric head traumas. The most frequent findings are those of subarachnoid hemorrhage and diffuse swelling	Need to review article to ascertain quality of study
11	Nau HE, Bongartz EB, Bock WJ, Weichert C (1979) Computerized tomography (CT), electroencephalography (EEG), and clinical symptoms in severe cranio-cerebral injuries: A comparative study. *Acta Neurochir (Wien)*, 45(3-4), pp 209-16	N=156 patients with craniocerebral injuries	CT was useful in detecting neurosurgical complications The clinical symptoms are reflected by EEG better than by CT	3-4

No.	Author, title, Journal, Year, vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
12	Merino-deVillasante J, Taveras JM (1976) Computerized tomography (CT) in acute head trauma *Am J Roentgenol*;126(4), Apr, pp 765-78	Retrospective study N=100	There is generally a direct relationship between the severity of clinical presentation and the CT demonstration of the abnormality responsible for the clinical status. Seventy percent of the patients clinically diagnosed as contusion had positive CT scans, and for all practical purposes, 100 percent of patients having trauma more severe than our Group III (contusion) had abnormal CT scans. Likewise, the number and intensity of tissue abnormalities on CT scans increase proportionately with the severity of the clinical signs and symptoms.	8
13	Hirsch W, Schobess A, Eichler G, Zumkeller W, Teichler H, Schluter A (2002) Severe head trauma in children: cranial computer tomography and clinical consequences. *Paediatr Anaesth* ;12(4), May, pp 337-44	Retrospective N=248 children	The initial CCT was of importance regarding further therapy, especially for children in need of surgical treatment. In the other cases, there was no direct impact from CCT findings on treatment procedures in the paediatric intensive care unit. The initial CCT was related to the prognosis, which can be poor even if there are only minimal changes in CCT, such as focal oedema or isolated ventricular bleeding.	5
14	Mattioli C, Beretta L, Gerevini S, Veglia F, Citerio G, Cormio M, Stocchetti N (2003) Traumatic sub-arachnoid haemorrhage on the computerized tomography scan obtained at admission: a multicenter assessment of the accuracy of diagnosis and the potential impact on patient outcome. *J Neurosurg*, 98 (1), Jan, pp :37-42	N= 169 head-injured patients on admission to 12 Italian intensive care units F/up: 3-month.	The scans were collected for neurological review and were used for analysis together with data from a multicenter data base. A review committee found a high incidence of tSAH (61%) in patients with TBI and a moderate agreement among centres (K=0.57) Significant associations were observed between the presence and grading of tSAH and patient oputcomes, and between the presence of tSAH and the severity of the CT findings. Conclusion: Traumatic tSAH is associated with more severe CT findings and a worse patient outcome.	4

No.	Author, title, Journal, Year, vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
15	Wardlaw JM, Easton VJ, Statham P.(2002) Which CT features help predict outcome after head injury? *J Neurol Neurosurg Psychiatry*, 72(2), feb, pp 188-92	425 baseline CT scans were reviewed for patients with all grades of traumatic head injury in a head injury registry, in which baseline demographic and injury status and outcome at 1 year were recorded.	CT scan variables are independent prognostic variables, and might help to identify patients at high risk of death at the time of admission.	5
16	Pillai S, Praharaj SS, Mohanty A, Kolluri VR. (2001) Prognostic factors in children with severe diffuse brain injuries: a study of 74 patients. *Pediatr Neurosurg*. 34(2), Feb, pp 98-103	Retrospective study. N= 74 children f/up: 1992 and 1998	These factors were found to be independent predictors of poor outcome. When these subjected to a stepwise logistic regression analysis, the most important variables for predicting outcome were oculocephalic reflex and GCS, which together correctly predicted unfavourable outcome with a sensitivity of 79% and a specificity of 65%. An early CT scan or a single CT scan did not have any prognostic significance.	5
17	Fearnside MR, Cook RJ, McDougall P, McNeil RJ. (1993) The Westmead Head Injury Project Outcome in Severe Head Injury. A comparative analysis of pre-hospital, clinical and CT variables. *Br.J Neurosurg*; 7(3), pp 267-79	Prospective study N= 315 consecutive pts	Analysis by logistic regression. The most accurate model of prediction of outcome (accuracy 72.5 %) included increasing age,abnormal motor responses and Three CT indicators (cerebral edema,intraventricular blood and degree of midline shift)	5
18	Selladurai BM, Jayakumar R, Tan YY, Low HC. (1992) Outcome prediction in the early management of severe Head injury:An experience in Malaysia. *Br.J Neurosurg*; 6 (6):549-57	Retrospective study on 109 pts with severe head injury in relation to clinical and CT criteria on admission after resuscitation.	1.Age ,GCS and atate of pupils strongly correlated with outcome. 2.Ct indicators associated with poor outcome were identified-cistern obliteration,diffuse axonal injury and acute subdural bleed.	5

No.	Author, title, Journal, Year, vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade and Comments
19	Toutant SM, Klauber MR, Marshall LF, Toole BM, Bowers SA, Seelig JM, Varnell JB. (1984) Absent or compressed basal cisterns on first CT scan: ominous predictors of outcome in severe head injury. *J.Neurosurg*, 61(4), pp 691-4	N= 218 pts	Outcome could be directly related to the status of the basal cisterns on the initial CT scan after adjusting for the GCS score.	5
20	Lipper MH, Kishore PR, Enas GG, Domingues da Silva AA, Choi SC, Becker DP.(1985) Computed Tomography in the prediction of outcome in head injury. *Am J Roentgeno*,144(3), Mac, pp 483-6	Retrospective analysis N= 128 randomly selected severe head injury pts managed on a standard protocol using linear logistic regression.	Correct prediction rate of outcome using proposed scale for CT findings alone was 69.7 % and increased to 75.8 % when combined with GCS score.	5
21	Azian AA, Nurulazman AA, Shuaib L, Mahayidin M, Ariff AR, Naing NN, Abdullah J (2001) Computed tomography of the brain in predicting outcome of traumatic intracranial haemorrhage in Malaysian patients *Acta Neurochir*, 143(7), pp 711 - 20	N= 103 cases	Significant predictors of outcome was the CT scan findings, the CT predictors of outcome include ICH, EDH, IVH, present of SAH, site of ICH, volumes of EDH and SDH as well as midline shift.	7

Intracranial Pressure

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
1	Thomas A, Berlinghof HG, Bock KH, Lampl L (2000) Outcome factors in severe skull-brain trauma. A retrospective analysis of 228 patients *Aneth Inten Nofrallmed Schmerzther*, 35(2), Feb, pp 91	Retrospective N= 228	Prehospital hypotension and hypoxia have a significant negative impact on outcome by causing secondary brain damage Increasing age influences outcome negatively Level of CCP (not ICP) as well as tromethamine and/or thiopentone treatment for control of elevated ICP were significantly correlated with outcome	8
2	Juul N, Morris GF, Marshall SB, Marshall LF (2000) Intracranial hypertension and cerebral perfusion pressure: influence on neurological deterioration and in severe head injury, The executive committee of the international Selfotel Trial *J Neurosurg*, 92(1), Jan, pp 1 – 6	Not stated	The most powerful predictors of neurological worsening was the presence of intracranial hypertension (ICP . or + 20 mmHg) either initially or during neurological deterioration	8
3	Celli P, Fruin A, Cervoini L (1997) Severe head trauma, review of the factors influencing the prognostic *Minerva Chir*, 52(12), Dec , pp 1467 – 80	N= 72 patients	Intracranial hypertension was a definitely ominous predictor only if very high when the risk to be or become uncontrollable seems to be much elevated	9
4	Resnick DK, Mrion DW, Carlier P (1997) Outcomes analysis of patients with severe head injuries and prolonged intracranial hypertension *J Trauma*, 42(6), Jun, pp 1128-11	N= 37 patients F/up: 1 year	When patient with good ourcome (GOS 4 or5) were compared with those with poor outcomes (GOS 1-3), no significant differences in mean or peak ICP, percentage of te intervals, with elevated ICP, lowest recored CPP, or length of ICP monitoring were detected	9

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
5	Fearnside MR, Cook RJ, McDougall P, McNeil RJ. (1993) The Westmead Head Injury Project outcome in severe head injury. A comparative analysis of pre-hospital, clinical and CT Variables *Br J Neurosurg,* 7(3), pp 267-79	Prospective study N= 315 patients F/up: 6 months	Predictors of mortality were increasing age, the presence of hypotension, a low GCS, abnormal motor responses and papillary non-reactivity Patient in whom intracranial pressure (ICP) was measured, raised ICP and failure to respond to treatment for raised ICP also predicted mortality The model which provided the most accurate prediction or poor outcome included age, hypotension, and three different CT characteristics, subarachnoid blood , intracerebral haematoma or intracerebral contusion (accuracy 72.5%)	7
6	Miller JD, Butterworth JF, Gudeman SK, Faulkner JE, Choi SC, Selhorst JB, Harbison W, Lutz H, Young HF, Becker DP (1981) Further experience in the management of severe head injury *J Neurosurge,* 54(3), Mar, pp 289-99	Prospective & Consecutive series N= 255 patients	Factors important in predicting a poor outcome included the presence of intracranial hematoma, increasing age, abnormal motor responses, impaired or absent eye movements or pupil light reflexes, early hypotension, hyposemia or intracranial pressure over 20 mm HG despite artificial ventilation.	8
7	Labato RD, Alen JF, Perez-Nun ez A, Alday R, Go Mez PA, Pascual B, Lagares A, Miranda P, Arrese I, Kaen A (2005) Value of serial CT scanning and intracranial pressure monitoring for detecting new intracranial mass effect in severe head injury patients showing lesions type I-II in the initial CT scan *Neurocirugia,* 16(3),Jun, pp 217 -.34	N= 56 patient	The presence of severe intra cranial hypertension significantly increased the risk of death	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
8	Schreiber MA, Aoki N, Scott BG , Beck JR. (2002) Determinant of mortality in patients with severe blunt head injury *Arch Surg*, 137(3), Mar, pp 28 5- 90	Validation cohort study	Intracranial hypertension are the only independent risk factors for mortality that can be readily treated during initial management of patient with severe head injury	6

Age

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
1	Miller JD, Butterworth JF, Gudeman SK, Faulkner JE, Choi SC, Selhorst JB, Harbison W, Lutz H, Young HF, Becker DP (1981) Further experience in the management of severe head injury *J Neurosurge*, 54(3), Mar, pp 289-99	Prospective & Consecutive series N= 255 patients	Factors important in predicting a poor outcome was increasing age	8
2	Fearnside MR, Cook RJ, McDougall P, McNeil RJ. (1993) The Westmead Head Injury Project outcome in severe head injury. A comparative analysis of pre-hospital, clinical and CT Variables *Br J Neurosurg*, 7(3), pp 267-79	Prospective study N= 315 patients F/up: 6 months	The model which provided the most accurate prediction or poor outcome included age	7
3	Thomas A, Berlinghof HG, Bock KH, Lampl L (2000) Outcome factors in severe skull-brain trauma. A retrospective analysis of 228 patients *Aneth Inten Nofrallmed Schmerzther*, 35(2), Feb, pp 91-7	Retrospective N= 228	Increasing age influences outcome negatively	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
4	Schreiber MA, Aoki N, Scott BG , Beck JR. (2002) Determinant of mortality in patients with severe blunt head injury *Arch Surg*, 137(3), Mar, pp 28 5- 90	Validation cohort study	Advance aged were found to be highly correlated risk factor of mortality in severe head injury patients	6
5	Selladurai BM, Jayakumar R, Tan YY , Low HC (1992) Outcome prediction in early management of severe head injury: an experience in Malaysia *Br J Nerurosurg*, 6(6), pp 549-57	N=109 patients	Age was a strongly correlated with outcome	8
6	Ono J, Isobe K, Waranable Y, Yamaura A (1993) Clinical problems in the management of aged patients with severe head injury: analysis of neurological findings and CT findings *No Shinkei Geka*, 21(8), Aug, pp 717 – 21	N= 457 patients	The outcome was significantly poor in the aged	8
7	Luerssen TG, Klauber MR , Marshall LF (1988) Outcome from head injury related to patient's age: a longitudinal prospective study of adult and pediatric head injury *J Neurosurg*, 68(3), Mar, pp 409- 16	Multicentre prospective study N= 8814 patients	Study indicate that age itself, even within the pediatric age range, is a major independent factor affecting the mortality rate in head injury patiet	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
8	Mwanng'Ombe NJ, Kiboi J (2001) Factors influencing the outcome of severe head injury at Kenyatta National Hospital *East Afr Med J*, 78(5), May, pp 238-41	N= 677 patients	Factor associated with poor outcomes in severe head injury patients at Kenyatta National Hospital was age.	8
9	Celli P, Fruin A, Cervoni L (1997) Severe headtrauma: Review of the factors influencing the prognosis *Minerva Chir*, 52(12), Dec, pp 1467-80	N= 72 patient	Old age prior to and upon admission positively worsened the outcome	8
10	Yamamto T, Mori K , Maeda M (2002) Assessment of prognostic factors in severe traumatic brain injury patients treated by mild therapeutic cerebral hypothermia therapy *Neurol Res, 2*4(8), Dec, pp 789-95	Case report N=37 patients	Patient aged over 50 years had poor outcome	

Abnormal Papillary Reaction

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
1	Selladurai BM, Jayakumar R, Tan YY, Low HC (1992) Outcome prediction in early management of severe head injury: an experience in Malaysia *Br J Neurosurg*, 6(6), pp 549-57	N= 109 patients	State of pupils strongly correlated with outcome	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
2	Miller JD, Butterworth JF, Gudeman Sk, Faulkner JE, Choi SC, Selhorst JB, Harbison JW, Lutz HA, Young HF, Becker DP(1981) Further experience in the management of severe head injury *J Neurosurg*, 54(3), pp 289-99	N= 225 patients	Important factor in predicting a poor outcome was the impaired or absent eye movement or pupil light reflexes	8
3	Matsumae M, Ishizaka H, Shiramizu H, Shibata M, Tsugane R (2001) Pupillary abnormality on admission and brain bulging during surgeru as unfavaurable predictors in patients treated with hypothermia *Acta Neurochirs*, 143(12), Dec, pp 1229-34	Retrospective review N= 81 patients with severe head injury	Independent factor predicting unfavorable outcome was papillary abnormality on admission	8
4	Prasad MR, Ewing-Cobbs L, Swank PR, Kramer L (2002) Predictors of outcome following traumatic brain injury in young children *Pediatr Neurosurg*, 36(2), Feb, pp 64-7	Longitudinal prospective study N= 60 children	Pupillary abnormalities were associated with poorer motor outcom	7
5	Pillai S, Praharaj SS, Mohanty A, Kolluri VR (2001) Prognostic factors in children with severe diffuse brain injuries: a study of 74 patients *Pediatr Neurosurg.* 34(2), Feb, pp 98-103	N= 74 children F/up: 6 yrs	The independent predicting factor of poor outcome was absent of papillary reaction.	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
6	Pfenninger , Santi A (2002) Severe traumatic brain injury in children are: the results improving? *Swiss Med Wkly*, 132, pp 116 - 20	N= 51 children F/up: 4 yrs	Bad outcome was associated with fixed and dilated pupil at admission	8
7	Scheiber Ma. Aoki N, Scott BG, Beck JR (2002) Determinants of mortality in patients with severe blunt head injury *Arch Surg*, 137(3), Mar, pp 285 -90	Validation cohort study	The risk factor associated with death is absence of papillary light reflex	6
8	Mwang'ombe NJ , Kiboi J (2001) Factors influencing the outcome of severe head injury at Kenyatta National Hospital *East Afr Med J*, 78(5), May, pp 238-41	Retrospective study N=670 patients F/up: 4 yrs	90% of the patients who had bilaterally dilated pupils not reacting to light on admission die and 66% of the patients with bilateral constricted pupils at the time of admission died. 20% of patients who had normal papillary reaction to light at the time of admission died.	6
9	Fearnside MR, Cook RJ, McDougall P, McNeil RJ (1993) The Westmead Head Injury Project outcome in severe head injury. A comparative analysis of pre hospital, clinical and CT variables *J Neurosurg*, 7(3), pp 267-79	Prospective study N= 315 patients	Predictors of mortality was non-reactivity papillary	8

Hypotension, hypoxemia or hypercarbia

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
1	Scheiber Ma. Aoki N, Scott BG, Beck JR (2002) Determinants of mortality in patients with severe blunt head injury *Arch Surg*, 137(3), Mar, pp 285 -90	Validation cohort study	Systemic hypotension in the emergency department was associated with mortality. It also only independent risk factor for mortality that can be readily treated during initial management of patient with severe head injury	6
2	Fearnside MR, Cook RJ, McDougall P, McNeil RJ (1993) The Westmead Head Injury Project outcome in severe head injury. A comparative analysis of pre hospital, clinical and CT variables J Eurosurg, 7(3), pp 267-79	Prospective study N= 315 patients	the most accurate prediction of poor outcome in severe head injury was hypotension	8
3	Mwang'ombe NJ , Kiboi J (2001) Factors influencing the outcome of severe head injury at Kenyatta National Hospital East Afr Med J, 78(5), May, pp 238-41	Retrospective study N=670 patients F/up: 4 yrs	85% of patients with systolic BP of less than 90 mmHg on admission died while 60% of those with systolic BP greater than 120 mmHg died. Factor associated with poor outcome in severe head injury patient in Kenyatta National Hospital was admission blood pressure (systolic).	6
4	Jeremitsky E, Omert L, Dunham Cm, Protetch J, Rodriquez A (2003) Harbigers of poor outcome the day after severe brain injury:hypothermia, hypoxia and hypoperfusion *J Trauma*, 54(2), Feb, pp 312 -9	Retrospective N=81	Hypotension, hyperglycemia, and hypothermia were associated with increase mortality rate	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
5	Adrews P, Sleeman DH, StathamPf, McQuatt A, Corruble V, Jones PA, Howlls TP, Macmillan CS (2002) Predicting recovery in patients suffering from traumatic brain injury by using admission variable and physiological data: a comparison between decision tree analysis and logistic regression *J Neurosurg*, 97(2), Aug, pp 326-36	N=124	The most significant predictors of mortality in this patient set were duration of hypotensive, prexic and hypoxemic insults. When good and pooor outcomes were compared, hypotensive insults and admission were significant	8
6	Manley G, Knudson MM, Morabito D, Damron S, Erickson V, Pitts L (2001) Hypotension, hypoxia, and head injury: Frequency, duration, and consequences *Arch Surg*, 136(10), Oct, pp 1118- 23	Prospective cohort study N= 107 patients	Hypotension, but not hypoxia, occurring in the initial phase of resuscitation is significantly associated with increased mortality following brain injury	6
7	Thomas A, Berlinghof HG, Bock KH, Lampl L (2000) Outcome factors in severe skull brain trauma *Anasthesiol Intersivmed Notfallmed Schmerzther*, 35(2), Feb, pp 91 – 7	Retrospective N=228	Prehospital hypotension and hypoxia have a significant negative impact on outcome by causing secondary brain damage	8
8	Ng I, Lew TW, Yeo TT, Seow WT, Tan KK, Ong PL, San WM (1998) Outcome patients with traumatic brain injury managed on a standardized head injury protocol *Ann Acad Med Singapore*, 27(3), May, pp 332 – 9	N= 48 consecutive patients	Good outcomes is related to early aggressive resuscitation to prevent hypotension and hypoxia, prompt evacuation of surgical mass lesions and the maintenance of an adequate cerebral perfusions pressure	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
9	Abraszko R, Zurynski Y, Dorsch N, Mudaliar Y (1997) Evaluation of treatment outcome in patient after extremely severe head injury (GCS 3-4) *Neuro Neruochir Pol*, 31(1), Jan – Feb, pp103 – 12	N= 62 patients	There was a statistically significant different in death rate, when hypotension was present at the scene	8
10	Stocchetti N, Furlan A, Volta F (1996) Hypoxemia and arterial hypotension at the accident scene in head injury *J Trauma*, 40(5), May, pp 764 -7	N= 49 consecutive patients	The outcome was significantly worse in cases of hypotension, desaturation or both	8
11	Wald SL, Shackford SR Fenwick J (1993) The effect of secondary insults on mortality and long term disability after severe head injury in a rural region without a trauma system *J Trauma*, 34(3), Mar, pp 377 -81	Prospective N= 170 patiens	Conclude that hypotension and hypoxia adversely effect the outcome of severe head injury	6
12	Chesnut RM, Marshall LF, Klauber MR, Nlunt BA, Baldwin N, Eisenberg HM, Jane JA, Marmarou A, Foulkes MA (1993) The role of secondary brain injury in determining outcome from severe head injury *J Trauma*, 34(2), Feb, pp 216 - 22	Prospective N= 717 cases	Hypotension was froundly detrimental, occurring in 34.6 % of these patients and associated with a 150% increase in mortality	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
13	Chesnut RM, Marshall SB, Piek J, Blunt BA, Klauber MR, Marshall LF (1993) Early and late systematic hypotension as a frequent and fundamental source of cerebral ischemia following severe brain injury in the Traumatic Coma Data Bank *Acta Neurochir Suppl (wein)*, 59, pp121-5	Prospective	For 117 patients whose only hypotensive episode occurred in the ICU, 66% either died or were vegetative survivors, compared to 17% of patients who never suffered and hypotensive episode. Logistic regression modeling suggested that early and late shock were the most powerful independent predictors of mortality in this group of patients	8
14	Lobato RD, Sarabia R, Cordobes F, Rivas JJ, Adrados A, Cabrera A, Gomez P, Madera A, Lamas E (1988) Post tramatic cerebral hemispheric swellin. Analysis of 55 cases studied with computerized tomography *J Neurosurge*, 68(3), Mar, pp 417 – 23	N= 55 patients	The high incidenct of arterial hypotnsion and or hypoxemia at admission (47% of cases) correlated with a very poor final outcome (87% mortality)	8
15	Kohi YM, Mendelow AD, Teasdale GM, Allardice GM. (1984) Estracranial insult and outcome in patients with acute head injury – relationship to the Glasgow Coma scale *Injury*, 16(1), Jul, pp 25 – 9	N= 67 patients	The combination of hypoxia and hypotension was uniformly fatal as was the presence of severe respiratory dysfunction	8
16	Miller JD, Butterworth JF, Gudeman SK, Faaulkner JE, Choi SC, Selhorst JB, Harbison JW, Lutz HA, Young HF, Becker DP (1981) Further experience in the management of severe head injury *J Neurosurge*, 54(3), Mar, pp 289 – 99	Consecutive series N= 225 patients	Factors important in predicting a poor outcome included presence of early hypotension and hypoxemia	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
17	Nirula R, Gentilello LM (2004) Futility of resuscitation criteria for the " young: old and the 'old" old trauma patients : a national trauma data bank analysis *J Trauma*, 57(1), pp 37 -41	N= 76 304 patients	Patients with moderate to severe head injury with admission SBP less than 90 mmHg, have mortality rate approaching to 100 %	6

Abnormal Motor Responses

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
1	Fearnside MR, Cook RJ, McDougall P, McNeil RJ (1993) The Westmead Head Injury Project outcome in severe head injury. A comparative analysis of pre hospital, clinical and CT variables *J Eurosurg*, 7(3), pp 267-79	Prospective study N= 315 patients	Predictor of mortality in severe head injury the presence of abnormal motor response	8
2	Miller JD, Butterworth JF, Gudeman SK, Faaulkner JE, Choi SC, Selhorst JB, Harbison JW, Lutz HA, Young HF, Becker DP (1981) Further experience in the management of severe head injury *J Neurosurge*, 54(3), Mar, pp 289 – 99	Consecutive series N= 225 patients	The important predicting a poor outcome in severe head injury patients was abnormal motor responses	8

Hyperglycemia

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
1	Cochran A, Scaife ER, Hansen KW, Downey EC (2003) Hyperglycemia and outcomes from pediatric traumatic brain injury *J Trauma*, 55(6), Dec, pp 1035 - 8	Traumatic patients admitted during single year to regional padiatric referral center	Patients who died had significantly higher admission serum glucose values than those patients who survived (267 mg/dL vs 135 mg/dL) admission serum glucose > or = 300 mg/dL was uniformly associated with death	7
2	Paret G, Tirosh R, Lotan D, Stein M, Ben- Abraham R, Vardi A, Harel R, Barzilay Z (1999) Early prediction of neurological outcome after falls in children: metabolic and clinical markers *J Accid Emerg Med*, 16(3), May, pp 186 – 8	Retrospective review N= 61 children	Children with a poor outcome had , at admission significantly higher glucose concentration compared with children with good outcomes.	8
3	Yang SY, Zhang S, Wang ML (1995) Clinical significance of admission hyperglycemia and factors related to it in patients with acute severe head injury *Surg Neurol*, 44(4), Oct, pp 373- 7	N = 83 patients (48 adults with severe head injury and 35 normal adults)	Ninety percent of the patients with blood glucose levels of 9.6 mmpl/L (171.4 mg/100mL) at admission died within the first month of injury. In the patient with lower glucose levels the mortality rate was 15%	8
4	Wallia S, Suteliffe AJ (2002) The relationship between blood glucose, mean arterial pressure and outcome after severe head injury : an observational study. *Injury*, 33(4), pp 339 – 4	Observation study N= 338 patients	Lower mean arterial pressure , hyperglycaemia is associated with increasing mortality. However further studies of the combined effect of hyperglycaemia and hypotension on mortality after severe head injury	8

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
5	Rovlias A , Kotsou S (2000) The influence of hyperglycemia on Neurological outcome in patient with severe head injury *Neurosurge,* 46(2), Feb, pp 335	Prospective study N= 267 patients	Patient who had an unfavorable outcome had significantly higher glucose levels than did those with a better prognosis. Among the patients with more severe head injury, a glucose level greater thatn 200 mg/dl was associated with a worse outcome	7
6	Jeremitsky E, Omert L, Dunham CM, Willberger J J, Rodriguez A (2005) The impact of hyperglycemia on patient with severe brain injury *J Trauma*, 58(1), Jan, pp 47 -50	Retrospective N= 77 patients	Early hyperglycemia is associated with poor outcome for patients with severe traumatic brain injury.	8
7	Chiaretti A, De Benedictis R, Langer A, Di Rocco C, Bizzarri C, Iannelli A, Polidori G. (1998) Prognostic implications of hyperglycaemia in paediatric head injury. *Childs Nerv Syst*. 14 (9), Sept, pp 455-9.	N= 51 severe head injury children	87.5% of the patients with a Glasgow Coma Score (GCS) < or =8 (the average blood glucose level on admission was 237.8+/-92 mg/dl), A close correlation was also seen between the outcome and the blood glucose level. In fact, the blood glucose on admission was higher in the patients with a poor outcome, i.e. in those having a Glasgow Outcome Score (GOS) of 2 or 3 and in those who died (GOS 1), than in the patients with a good outcome (GOS of 4 or 5). Finally, hyperglycaemia persisted beyond the first 24 h after trauma in all the children who died or who survived with a poor outcome. Hyperglycaemia, and especially its persistence over time, appears to be an important negative prognostic factor in children with head injury.	8

Low Cerebral Perfusion Pressure

No.	Author, title, Journal, Year, Vol, Pg no	Study design, Sample size, Follow-up	Outcomes & characteristics	Grade & Comments
1	Dawnard C, Hulka F, Mullins RJ, Piat J, Chesnut R, Quint P, Mann NC (2000) Relationship of cerebral perfusion pressure and survival in pediatric brain injury patients *J Trauma*, 49(4), Oct, pp 654 -8	Retrospective study N= 188 brain injury children	No patient with mean CPP less than 40 mmHg survived. Low mean CPP was lethal. In children with survivable brain injury (mean CPP > 40 mHg) CPP did not stratify patient for risk of adverse outcome	8
2	Hackbarth RM, Rzeszutko KM, Sturm G, Donders J, Kuldanek AS, Sanfilippo DJ (2002) Survival and functional outcome in pediatric traumatic brain injury: a retrospective review and analysis of predictive factors *Crit Care Med*, 30(7), Jul, pp 1630-5	Retrospective review N= 320 consecutive pediatric patient F/up; 4 years	The ability to maintain a cerebral perfusion pressure of > or = 50 mmHg was the single most important predictor of traumatic brain injury survival.	8
3	Thomas A, Berlinghof HG, Bock KH, Lampl L (2000) Outcome factors in severe skull brain trauma *Anasthesiol Intersivmed Notfallmed Schmerzther*, 35(2), Feb, pp 91 – 7	Retrospective N=228	Mortality rate in 32 patients with CPP < 50 mmHg was 69% in 29 patients with CPP > than 50 mmHg only 20%. Patients treated with Tromethamine and Thiopentone because of uncontrollable intracranial hypertension showed significantly worse outcome.	8
4	Adrews P, Sleeman DH, StathamPf, McQuatt A, Corruble V, Jones PA, Howlls TP, Macmillan CS (2002) Predicting recovery in patients suffering from traumatic brain injury by using admission variable and physiological data: a comparison between decision tree analysis and logistic regression *J Neurosurg*, 97(2), Aug, pp 326-36	N=124	Low cerebral perfusion pressure is a best predictor of death.	8

No.	Author, title, Journal, Year, Vol, Pg no	Study design, Sample size, Follow-up	Outcomes & characteristics	Grade & Comments
5	Elf K, Nilsson P, Ronne-Engstrom E, Howells T, Enblad P (2005) Cerebral perfusion pressure between 50 and 60 mmHg may be beneficial in head injury patients: a computerized secondary insult monitoring study *Neurosurge*, 56(5), May, pp 962 - 71	N= 81 patients	CPP less than 60mmHg insults were significant predictors of favorable outcome in the final multiple logistic regression model.	8
6	Juul N, Morris GF, Marshall SB, Marshall LF (2000) Intracranial hypertension and cerebral perfusion pressure: influence on neurological deterioration and outcome in severe head injury. The executive committee of the international selfotel trial *J of Neurosurg*, 92(1), Jan, pp 1 – 6			

Oculocephalic Reflex

No.	Author, title, Journal, Year, Vol, pg no	Study design, sample size, follow-up	Outcomes & characteristics	Grade & Comments
1	Pillai S, Praharaj SS, Mohanty A, Kolluri VR (2001) Prognostic factors in children with severe diffuse brain injuries: a study of 74 patients *Pediatr Neurosurg*, 34(2)< Feb, pp 98-103	N= 74 patients	The independent factor of poor outcome was absent oculocephalic reflex	8