

Head Trauma EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Saul TG, and Joint Section on Neurotrauma and Critical Care of the American Association of Neurological Surgeons and Congress of Neurological Surgeons. Management of Head Injury, 1998.	Review/Other-Dx	N/A	Guidelines for management of acute head trauma patients.	N/A	4
2. Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM. Indications for computed tomography in patients with minor head injury. <i>N Engl J Med</i> 2000; 343(2):100-105.	Observational-Dx	1 st phase – 520 consecutive patients; 2 nd phase – 909 consecutive patients	Prospective study to derive and validate a set of clinical criteria that could be used to identify patients with MHI in whom CT could be forgone. The study was conducted in two phases at a large, inner-city, level 1 trauma center.	Of the 520 patients in the first phase, 36 (6.9%) had positive scans. All patients with positive CT scans had one or more of 7 findings: headache, vomiting, an age over 60 years, drug or alcohol intoxication, deficits in short-term memory, physical evidence of trauma above the clavicles, and seizure. Among the 909 patients in the second phase, 57 (6.3%) had positive scans. In this group of patients, the sensitivity of the 7 findings combined was 100% (95% CI, 95% to 100%). All patients with positive CT scans had at least one of the findings. For the evaluation of patients with MHI, the use of CT can be safely limited to those who have certain clinical findings.	3
3. Stiell IG, Wells GA, Vandemheen K, et al. The Canadian CT Head Rule for patients with minor head injury. <i>Lancet</i> 2001; 357(9266):1391-1396.	Observational-Dx	3,121 consecutive patients	Prospective cohort multicenter study to develop a highly sensitive clinical decision rule for use of CT in patients with minor head injuries.	A CT head rule was derived which consists of 5 high-risk factors (failure to reach GCS (G of 15 within 2 h, suspected open skull fracture, any sign of basal skull fracture, vomiting >2 episodes, or age >65 years) and two additional medium-risk factors (amnesia before impact >30 min and dangerous mechanism of injury). The high-risk factors were 100% sensitive (95% CI, 92%-100%) for predicting need for neurological intervention, and would require only 32% of patients to undergo CT. The medium-risk factors were 98.4% sensitive (95% CI, 96%-99%) and 49.6% specific for predicting clinically important brain injury, and would require only 54% of patients to undergo CT.	3
4. Haydel MJ. Clinical decision instruments for CT scanning in minor head injury. <i>JAMA</i> 2005; 294(12):1551-1553.	Review/Other-Dx	N/A	Overview of clinical decision making issues related to CT scanning of MHI subjects.	Differences in outcome measures, physician acceptance, practice and medical-legal environments and judgment affect scanning decision making.	4

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5. Smits M, Dippel DW, de Haan GG, et al. External validation of the Canadian CT Head Rule and the New Orleans Criteria for CT scanning in patients with minor head injury. <i>JAMA</i> 2005; 294(12):1519-1525.	Observational-Dx	3,181 consecutive patients	Prospective multicenter study to validate and compare the Canadian CT Head Rule (CCHR) to the New Orleans Criteria (NOR) in Dutch patients with head injuries.	Of 3,181 patients with a GCS score of 13 to 15, neurosurgical intervention was performed in 17 patients (0.5%); neurocranial traumatic CT findings were present in 312 patients (9.8%). Sensitivity for neurosurgical intervention was 100% for both the CCHR and the NOC. The NOC had a higher sensitivity for neurocranial traumatic findings and for clinically important findings (97.7%-99.4%) than did the CCHR (83.4%-87.2%). Specificities were very low for the NOC (3.0%-5.6%) and higher for the CCHR (37.2%-39.7%). The estimated potential reduction in CT scans for patients with MHI would be 3.0% for the adapted NOC and 37.3% for the adapted CCHR. CCHR is less sensitive for trauma or clinically relevant findings, but would identify all neurosurgical cases and reduce CT utilization.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
6. Stiell IG, Clement CM, Rowe BH, et al. Comparison of the Canadian CT Head Rule and the New Orleans Criteria in patients with minor head injury. <i>JAMA</i> 2005; 294(12):1511-1518.	Observational-Dx	CCHR evaluated in 2,707 adults CCHR and NOC compared in a subgroup of 1,822 adults	Prospective multicenter cohort study to compare the clinical performance of CCHR to the NOR for detecting the need for neurosurgical intervention and clinically important brain injury.	Among 1,822 patients with GCS of 15, 8 (0.4%) required neurosurgical intervention and 97 (5.3%) had clinically important brain injury. The NOC and the CCHR both had 100% sensitivity but the CCHR was more specific (76.3% vs 12.1%, $P<.001$) for predicting need for neurosurgical intervention. For clinically important brain injury, the CCHR and the NOC had similar sensitivity (100% vs 100%; 95% CI, 96%-100%) but the CCHR was more specific (50.6% vs 12.7%, $P<.001$), and would result in lower CT rates (52.1% vs 88.0%, $P<.001$). The kappa values for physician interpretation of the rules, CCHR vs NOC, were 0.85 vs 0.47. Physicians misinterpreted the rules as not requiring imaging for 4.0% of patients according to CCHR and 5.5% according to NOC ($P=.04$). Among all 2,707 patients with a GCS of 13 to 15, the CCHR had sensitivities of 100% (95% CI, 91%-100%) for 41 patients requiring neurosurgical intervention and 100% (95% CI, 98%-100%) for 231 patients with clinically important brain injury. For patients with MHI and GCS score of 15, the CCHR and the NOC have equivalent high sensitivities for need for neurosurgical intervention and clinically important brain injury, but the CCHR has higher specificity for important clinical outcomes than does the NOC, and its use may result in reduced imaging rates.	2

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7. Smits M, Dippel DW, de Haan GG, et al. Minor head injury: guidelines for the use of CT--a multicenter validation study. <i>Radiology</i> 2007; 245(3):831-838.	Observational-Dx	3,181 patients	To prospectively and externally validate published national and international guidelines for the indications of CT in patients with a MHI.	Only the European Federation of Neurological Societies guidelines reached a sensitivity of 100% for all outcomes. Specificity was 0.0%-0.5%. The Dutch guidelines had the lowest sensitivity (76.5%) for neurosurgical interventions. The best specificities for traumatic CT findings and neurosurgical interventions were reached with the criteria proposed by the United Kingdom National Institute for Clinical Excellence (NICE) (46.1% and 43.6%, respectively), albeit at relatively low sensitivities (82.1% and 94.1%, respectively). The number of patients needed to scan ranged from 6 to 13 for traumatic CT findings and from 79 to 193 for neurosurgical interventions. All validated guidelines demonstrated a trade-off between sensitivity and specificity. The lowest number of patients needed to scan for either of the outcomes was reached with the NICE criteria.	3
8. Smits M, Dippel DW, Nederkoorn PJ, et al. Minor head injury: CT-based strategies for management--a cost-effectiveness analysis. <i>Radiology</i> 2010; 254(2):532-540.	Review/Other-Dx	3,181 patients	To compare the cost-effectiveness of using selective CT strategies with that of performing CT in all patients with MHI. Data from the multicenter CT in head injury patients Study involving 3,181 patients with MHI were used.	Study results showed that performing CT selectively according to the CCHR or the CT in head injury patients rule could lead to substantial U.S. cost savings (\$120 million and \$71 million, respectively), and the CCHR was the most cost-effective at reference-case analysis. When the prediction rule had lower than 97% sensitivity for the identification of patients who required neurosurgery, performing CT in all patients was cost-effective. The CT in head injury patients rule was most likely to be cost-effective. At value-of-information analysis, the expected value of perfect information was \$7 billion, mainly because of uncertainty about long-term functional outcomes. Selecting patients with MHI for CT renders cost savings and may be cost-effective, provided the sensitivity for the identification of patients who require neurosurgery is extremely high. Uncertainty regarding long-term functional outcomes after MHI justifies the routine use of CT in all patients with these injuries.	4

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9. Masters SJ, McClean PM, Arcarese JS, et al. Skull x-ray examinations after head trauma. Recommendations by a multidisciplinary panel and validation study. <i>N Engl J Med</i> 1987; 316(2):84-91.	Review/Other-Dx	7,035 patients	Multidisciplinary panel of medical experts was assembled to review the issue of skull radiography for head trauma. The panel identified two main groups of patients—those at high risk of intracranial injury and those at low risk of such injury—and developed a management strategy for imaging in the two groups. A prospective study of 7,035 patients with head trauma at 31 hospital emergency rooms was conducted to validate the management strategy.	No intracranial injuries were discovered in any of the low-risk patients. Therefore, no intracranial injury would have been missed by excluding skull radiography for low-risk patients, according to the protocol. Authors conclude that use of the management strategy is safe and that it would result in a large decrease in the use of skull radiography, with concomitant reductions in unnecessary exposure to radiation and savings of millions of dollars annually.	4
10. Wei SC, Ulmer S, Lev MH, Pomerantz SR, Gonzalez RG, Henson JW. Value of coronal reformations in the CT evaluation of acute head trauma. <i>AJNR</i> 2010; 31(2):334-339.	Observational-Dx	213 patients	Prospective study to evaluate whether coronal reformations improve detection of intracranial hemorrhage in noncontrast cranial CT performed for head trauma.	Of 213 patients, 32 noncontrast cranial CT demonstrated intracranial hemorrhage (a total of 104 foci). 15/104 (14%) intracranial hemorrhages (8 patients) were detected solely on coronal images. Locations included the floor of the anterior and middle cranial fossas, vertex, corpus callosum, falx, tentorium, and occipital convexity. Coronal reformations allowed exclusion of suspicious findings on axial images in 14 instances (7 patients). Coronal images aided interpretation in 29/104 (28%) findings. Coronal reformations improve the detection of intracranial hemorrhage over axial images alone, especially for lesions that lie in the axial plane immediately adjacent to bony surfaces. The use of coronal reformations should be considered in the routine interpretation of head CT examinations performed for the evaluation of head trauma.	3

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11. Zacharia TT, Nguyen DT. Subtle pathology detection with multidetector row coronal and sagittal CT reformations in acute head trauma. <i>Emerg Radiol</i> 2010; 17(2):97-102.	Observational-Dx	200 patients	To retrospectively analyze the advantages of coronal and sagittal reformations obtained with MDCT in patients with acute head trauma. Images analyzed by two independent, blinded readers.	CT imaging abnormalities were detected in 55/200 patients who were scanned for head trauma. Acute traumatic intracranial abnormality was detected on axial scans in 45 patients. Subtle findings were confirmed on coronal and sagittal CT reformations in 10 cases, and these were undetected initially on axial CT. Coronal and sagittal reformations confirmed subtle findings in 18.2% (10/55) of the cases (P=0.001). Indeterminate neuroimaging findings confirmed by coronal and sagittal CT head reformations include tentorial and interhemispheric fissure subdural hemorrhage, subarachnoid hemorrhage, and inferior frontal and temporal lobe contusions. Overall, coronal and sagittal reformations improved diagnostic confidence and interobserver agreement over axial images alone for visualization of normal structures and in the diagnosis of acute abnormality.	2
12. National Cancer Institute USNIoH. Radiation risks and pediatric computed tomography (CT): a guide for health care providers. August 20, 2002; http://www.nci.nih.gov/cancertopics/causes/radiation-risks-pediatric-CT .	Review/Other-Dx	N/A	To review the value of CT and the importance of minimizing the radiation dose, especially in children. The following issues are addressed: CT as a diagnostic tool. Unique considerations for radiation exposure in children. Radiation risks from CT in children: a public health issue. Immediate strategies to minimize CT radiation exposure to children.	Recommendation of lower dose pediatric CT protocols, education to optimize exposure settings and assure need for CT and research scan quality/dose and CT associated radiation and cancer risk.	4
13. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. <i>Lancet</i> 1974; 2(7872):81-84.	Review/Other-Dx	N/A	Clinical scale for evaluation of impaired consciousness and coma is reviewed.	The scale facilitates consultations between general and special units in cases of recent brain damage, and is useful also in defining the duration of prolonged coma.	4

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14. Kido DK, Cox C, Hamill RW, Rothenberg BM, Woolf PD. Traumatic brain injuries: predictive usefulness of CT. <i>Radiology</i> 1992; 182(3):777-781.	Observational-Dx	72 patients	CT scans from patients with TBI were reviewed to determine whether a specific type, location, or size of lesion correlated with changes in neurologic function (assessed with the GCS), patient outcome (assessed with the GOS), or catecholamine levels.	GOS changed as a function of lesions size ($P=.00004$) in the 48 patients with focal hemorrhages, regardless of whether the lesions were intra- or extraaxial, and in the 19 patients with normal CT scans. Patients with lesions larger than 4,100 mm ³ had a twofold greater risk of a poor outcome than patients with smaller lesions (100% vs 50%). Patients with normal CT scans were significantly more likely to have mild neurological dysfunction or none than patients with abnormal CT scans ($P=.03$), but lesion location, skull fracture, and pineal shift were not significant predictors of GCS or GOS scores. A positive relationship existed between lesion size and both plasma norepinephrine and epinephrine levels ($P<.02$); a significant relationship existed between lesion size and GCS score ($P=.02$).	2
15. Reinus WR, Zwemer FL, Jr., Fornoff JR. Prospective optimization of patient selection for emergency cranial computed tomography: univariate and multivariate analyses. <i>Invest Radiol</i> 1996; 31(2):101-108.	Observational-Dx	551 patients	To determine if the clinical variables that are important for selecting patients for emergency cranial CT are population dependent.	Of 551 patients having cranial CT, neurologic examination was positive in 340 and CT scan was positive in 122. The neurologic examination correlated strongly with the results of the CT scan ($P<0.00001$). In this patient population, the most important clinical predictors of 17 abnormal CT scans from the 211 patients without positive neurologic examinations were seizure and a history of neoplasm. Abnormal neurologic examination is the most important criterion available to select patients for emergency cranial CT.	4

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16. Shackford SR, Wald SL, Ross SE, et al. The clinical utility of computed tomographic scanning and neurologic examination in the management of patients with minor head injuries. <i>J Trauma</i> 1992; 33(3):385-394.	Observational-Dx	2,766 patients	To determine the value of CT and neurologic examination in the management of patients with minor injuries. Hypothesis that normal CT and MHI have negligible risk of neurosurgical deterioration.	A neurologic examination and a CT scan were performed on 2,166 patients; 933 patients had normal neurologic examinations and normal CT scans and none required craniotomy; 1,170 patients had normal CT scans and none required craniotomy; 2,112 patients had normal neurologic examinations and 59 required craniotomy. The sensitivity of the CT scan was 100%, with PPV of 10%, NPV of 100%, and specificity of 51%. The use of CT alone as a diagnostic modality would have saved 3,924 hospital days, including 814 ICU days, and \$1,509,012 in hospital charges. CT scanning is essential in the management of patients with minor head injuries and if the neurologic examination is normal and the scan is negative patients can be safely discharged from the emergency room.	3

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17. Livingston DH, Loder PA, Hunt CD. Minimal head injury: is admission necessary? <i>Am Surg</i> 1991; 57(1):14-17.	Review/Other-Dx	138 patients	Retrospective study to determine whether normal CT could have avoided admission in MHI patients.	GCS was 15/103 patients (74%) and 14/35 (26%). 83 patients were admitted for their head injury alone, and 55 had other injuries but would have required admission for their head injury. Loss of consciousness was documented in 51% and suspected in another 29% and was distributed equally regardless of GCS. 7% (5/71) of skull radiographs were positive and were associated with central nervous system pathology in 3 patients. Skull radiographs in an additional 4 patients with positive CT findings were negative including a patient with an epidural hematoma. 17% (13/75) of CT scans were positive (contusions 5, subdural hematoma 3, subarachnoid hemorrhage 2, edema 2, and epidural hematoma 1). Only the patient with the epidural hematoma required operative treatment. No patient with a normal CT scan went on to develop any neurosurgical problems, and 78% of the patients admitted with isolated head injuries were discharged within 48 hours. Significant central nervous system pathology does occur following “minimal” head injuries. Skull radiographs are not helpful. The use of CT scanning appears to triage those patients requiring admission and in hospital observation.	4

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18. Nagy KK, Joseph KT, Krosner SM, et al. The utility of head computed tomography after minimal head injury. <i>J Trauma</i> 1999; 46(2):268-270.	Observational-Dx	1,170 patients	Prospective study to determine if patients who present with a history of loss of consciousness who are neurologically intact (minimal head injury) should be managed with head CT, observation, or both.	All patients had GCS scores of 15 on arrival and had a history of either loss of consciousness or amnesia to the event. 247 patients (21.1%) were intoxicated with drugs or alcohol on admission; 39 patients (3.3%) had abnormalities detected by CT, including 18 intracranial bleeds; 21 patients (1.8%) had changes in therapy as a direct result of their CT results, including 4 operative procedures. No patient with negative CT results deteriorated during the subsequent observation period. CT is a useful test in patients with minimal head injury because it may lead to a change in therapy in a small but significant number of patients. Subsequent hospital observation adds nothing to the CT results and is not necessary in patients with isolated minimal head injury.	3
19. Stein SC, O'Malley KF, Ross SE. Is routine computed tomography scanning too expensive for mild head injury? <i>Ann Emerg Med</i> 1991; 20(12):1286-1289.	Review/Other-Dx	658 consecutive patients	Retrospective record review. To compare relative costs of treating mildly head-injured patients by routine admission or by using skull radiographs or cranial CT scanning to screen patients for admission.	The average cost if every patient had been admitted for observation given skull radiographs, with CT scans done on those exhibiting skull fracture or later deterioration, was \$1,207. If the CT scan had been used to identify patients with intracranial lesions and the others had been discharged, costs would have been almost 10% less. Had skull radiography been used to screen admissions, costs would have been 22% below those of routine CT scanning. However, these small savings are likely to be reduced by additional expenses related to missed intracranial lesions. Every patient with loss of consciousness or post-traumatic amnesia should have routine CT scanning. If the scan is normal and there are no other reasons for admission, the patients can be discharged safely from the emergency department. This represents optimal care from a medical standpoint and is justified from a cost-effectiveness point of view.	4

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20. Stiell IG, Clement CM, Grimshaw JM, et al. A prospective cluster-randomized trial to implement the Canadian CT Head Rule in emergency departments. <i>CMAJ</i> 2010; 182(14):1527-1532.	Observational-Dx	4,531 patients; 12 sites (6 randomly allocated as intervention sites and 6 as control sites)	To evaluate the effectiveness of implementing CCHR at multiple emergency departments using a matched-pair cluster-randomized trial.	Baseline characteristics of patients were similar when comparing control to intervention sites. At the intervention sites, the proportion of patients referred for CT imaging increased from the “before” period (62.8%) to the “after” period (76.2%) (difference +13.3%, 95% CI, 9.7%-17.0%). At the control sites, the proportion of CT imaging usage also increased, from 67.5% to 74.1% (difference +6.7%, 95% CI, 2.6%-10.8%). The change in mean imaging rates from the “before” period to the “after” period for intervention vs control hospitals was not significant (P=0.16). There were no missed brain injuries or adverse outcomes.	3
21. Stein SC, Spettell C, Young G, Ross SE. Delayed and progressive brain injury in closed-head trauma: radiological demonstration. <i>Neurosurgery</i> 1993; 32(1):25-30; discussion 30-21.	Observational-Dx	337 consecutive patients	To determine incidence of new or worsening intracranial lesions on CT after head injury.	149 (44.5%) of 337 consecutively studied patients developed delayed brain injury. There were highly significant associations (P<0.001) between the appearance of delayed cerebral insults and the severity of the initial brain injury, the need for cardiopulmonary resuscitation in the field, the presence of coagulopathy at admission, and subdural hematoma on the initial CT scan. In addition, delayed injury was associated (P<0.001) with higher mortality, slowed recovery, and poorer outcome at 6 months.	3
22. Gaskill-Shipley MF, Tomsick TA. Angiography in the evaluation of head and neck trauma. <i>Neuroimaging Clin N Am</i> 1996; 6(3):607-624.	Review/Other-Dx	N/A	Review role of angiography in evaluation of head and neck trauma.	Angiography is primary tool for traumatic vascular lesions.	4

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23. Ozdoba C, Sturzenegger M, Schroth G. Internal carotid artery dissection: MR imaging features and clinical-radiologic correlation. <i>Radiology</i> 1996; 199(1):191-198.	Observational-Dx	31 patients	To retrospectively analyze the usefulness of MRI techniques and diagnostic sensitivity in internal and carotid artery dissection and to correlate these findings with those of other imaging modalities and with clinical signs.	T1-weighted fat-suppressed MRI most accurately demonstrated intramural hematoma in the ICA in all patients. Kinking or coiling of the ICA was found in 9 (29%) patients. Hyperintense signal was seen on T1- and T2-weighted images in the carotid canal or in the cavernous sinus in two-thirds of the patients. Findings characteristic of internal and carotid artery dissection were seen on 13/16 angiograms. MRI most accurately demonstrated internal and carotid artery dissection. The high rate of kinking and coiling in the carotid artery suggests that these anatomic conditions may be predisposing factors.	3
24. Showalter W, Esekogwu V, Newton KI, Henderson SO. Vertebral artery dissection. <i>Acad Emerg Med</i> 1997; 4(10):991-995.	Review/Other-Dx	2	Case report on two cases of vertebral artery dissections with delayed recognition following motor vehicle collisions.	The first vertebral artery dissections patient developed major neurologic abnormalities 28 hours after an motor vehicle collision. The second vertebral artery dissections patient presented with 3 weeks of neck and head pain beginning 8 weeks after an motor vehicle collision and subsequent chiropractic manipulation.	4
25. Krings T, Geibprasert S, Lasjaunias PL. Cerebrovascular trauma. <i>Eur Radiol</i> 2008; 18(8):1531-1545.	Review/Other-Dx	N/A	To describe clinical and imaging findings, diagnostic and treatment strategies in arterial lesions.	No results stated.	4

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26. Delgado Almandoz JE, Schaefer PW, Kelly HR, Lev MH, Gonzalez RG, Romero JM. Multidetector CT angiography in the evaluation of acute blunt head and neck trauma: a proposed acute craniocervical trauma scoring system. <i>Radiology</i> 2010; 254(1):236-244.	Observational-Dx	830 consecutive patients	Retrospective study to determine the diagnostic yield of MDCT angiography in the evaluation of patients presenting to the emergency department with acute blunt head and neck trauma to assess for arterial injury and to propose a practical scoring system for the identification of patients at highest risk of arterial injury.	MDCT angiographic results showed injury to 118 arterial structures in 106 (12.8%) patients. Multivariate logistic regression analysis showed that the presence of cervical interfacetal subluxation/dislocations (44.4%; OR, 6.3; P<.0001), fracture lines reaching an arterial structure (22.1%; OR, 4.4; P < .0001), and high-impact mechanism of injury (16.5%; OR, 3.1; P<.0001) were independent predictors of an increased risk of arterial injury and were used to construct a scoring system. Patients with scores of 2 and 3 (21.9% and 52.2%, respectively) were at highest risk of arterial injury. The proposed acute craniocervical trauma scoring system could be used as a guide to select blunt trauma patients for MDCT angiographic evaluation. Future validation of this scoring system is necessary.	3

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27. Mirvis SE, Wolf AL, Numaguchi Y, Corradino G, Joslyn JN. Posttraumatic cerebral infarction diagnosed by CT: prevalence, origin, and outcome. <i>AJNR</i> 1990; 11(2):355-360.	Review/Other-Dx	1,332 patients	Retrospective study of infarction in head trauma patients to determine frequency, cause, and influence of post-traumatic cerebral infarction on mortality.	Post-traumatic cerebral infarction was diagnosed by CT within 24 hours of admission (10 patients) and up to 14 days after admission (mean, 3 days) in 25 (1.9%) of 1,332 patients who required cranial CT for trauma during the period. Infarcts, in well-defined arterial distributions, were diagnosed either unilaterally or bilaterally in the posterior cerebral (17), proximal and/or distal anterior cerebral (11), middle cerebral (11), lenticulostriate/thalamoperforating (9), anterior choroidal (3), and/or vertebrobasilar (2) territories in 23 patients. CT findings suggested direct vascular compression due to mass effects from edema, contusion, and intra- or extraaxial hematoma as the cause of infarction in 24 patients; there was postmortem verification in five. Mortality in craniocerebral trauma with complicating post-traumatic cerebral infarction, 68% in this series, did not differ significantly from that in craniocerebral trauma patients without post-traumatic cerebral infarction when matched for admission GCS results. Thus, aggressive management should be considered even in the presence of post-traumatic cerebral infarction.	4

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28. Gentry LR, Godersky JC, Thompson B, Dunn VD. Prospective comparative study of intermediate-field MR and CT in the evaluation of closed head trauma. <i>AJR</i> 1988; 150(3):673-682.	Observational-Dx	40 patients	Prospectively evaluate patients with acute closed head trauma to determine: 1) the feasibility of MRI for evaluating these patients, and 2) the relative sensitivities of CT and MRI for detecting various types of cerebral injuries.	CT and MRI (T1- and T2-weighted) studies were both highly and comparably sensitive in the detection of hemorrhagic intraaxial lesions. MRI scans, however, were much more sensitive in detecting nonhemorrhagic lesions. Cortical contusions and DAI constituted 91.9% of all intraaxial lesions. The sensitivities of the imaging techniques for this combined group of lesions were 1) nonhemorrhagic lesions (CT = 17.7%, T1-weighted MRI = 67.6%, T2-weighted MRI = 93.3%); 2) hemorrhagic lesions (CT = 89.8%, T1-weighted MRI = 87.1%, T2-weighted MRI = 92.5%). MRI was also significantly better in detecting brainstem lesions (CT = 9.1%, T1-weighted MRI = 81.8%, T2-weighted MRI = 72.7%). The sensitivities of the diagnostic studies in the detection of extraaxial hematomas were CT = 73.2%, T1-weighted MRI = 97.6%, T2-weighted MRI = 90.5%). Intraventricular hemorrhage was consistently seen with all three imaging studies, but subarachnoid hemorrhage was detected much more frequently with CT. MRI has clear advantages over CT in evaluating closed head trauma. Although its sensitivity in detecting hemorrhagic lesions is similar to that of CT, it is much better than CT in detecting nonhemorrhagic lesions, which are more prevalent. MRI is more useful than CT in classifying primary and secondary forms of injury and directing treatment. CTs one advantage over MRI is its ability to more rapidly assess unstable patients who may need surgery.	2

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29. Mittl RL, Grossman RI, Hiehle JF, et al. Prevalence of MR evidence of diffuse axonal injury in patients with mild head injury and normal head CT findings. <i>AJNR</i> 1994; 15(8):1583-1589.	Observational-Dx	20 consecutive patients; 2 blinded readers	Prospective study to assess the prevalence of MRI evidence for DAI at 1.5 T in patients with normal head CT findings after mild head injury.	The readers agreed that abnormalities compatible with DAI were present in the white matter of 6 (30%) of 20 patients (95% CI, 12% to 54%). Both readers agreed that foci of high signal intensity were present on the T2-weighted spin-echo sequence in 3 (15%) of the 20 cases (95% CI, 3% to 38%) and that foci of hypointensity compatible with hemorrhagic shear injury were present on the T2-weighted sequence in 4 (20%) of the 20 patients (95% CI, 6% to 44%). Both types of abnormality were noted by the readers in one patient. MRI shows evidence of DAI in some patients with normal head CT findings after mild head injury. These lesions may represent the pathologic substrate underlying the postconcussion syndrome that occurs in many patients with moderate to severe head injury.	1
30. Kampfl A, Schmutzhard E, Franz G, et al. Prediction of recovery from post-traumatic vegetative state with cerebral magnetic-resonance imaging. <i>Lancet</i> 1998; 351(9118):1763-1767.	Observational-Dx	80 patients; 3 blinded reviewers	To define the MRI signs of cerebral injury in patients in post-traumatic vegetative state. Authors also examined whether lesions in certain brain areas can predict that there will be non-recovery from a post-traumatic vegetative state.	Cerebral MRI findings in the subacute stage after head injury can predict the outcome of the post-traumatic vegetative state. Corpus callosum and dorsolateral brainstem lesions are highly significant in predicting non-recovery.	2
31. Fiser SM, Johnson SB, Fortune JB. Resource utilization in traumatic brain injury: the role of magnetic resonance imaging. <i>Am Surg</i> 1998; 64(11):1088-1093.	Observational-Dx	40 patients had 79 CT scans and 40 MRIs	Retrospective review to determine whether MRI influenced the acute diagnosis and management of TBI patients.	9 patients (22.5%) had injuries on CT scan but not on MRI; most commonly skull fractures or small subarachnoid hemorrhages. 24 patients (60%) had injuries on MRI but not on CT scan, most commonly corpus callosum shear injuries. There were 2 cases of child abuse and both had injuries of varying ages identified by MRI, but not CT. All injuries requiring a therapeutic intervention or change in management were identified by CT scan. MRI identified one patient with a traumatic ICA thrombosis. The performance of MRI resulted in additional charges of \$75,640 or \$3,152/patient identified with a new lesion. Although MRI identifies lesions not evident on CT scan, MRI does not alter management plans and is of limited value in the acute management of TBI. MRI may be of medicolegal benefit in cases of child abuse.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
32. Ashikaga R, Araki Y, Ishida O. MRI of head injury using FLAIR. <i>Neuroradiology</i> 1997; 39(4):239-242.	Observational-Dx	56 patients	To examine the utility of fluid-attenuated inversion-recovery MRI in the investigation of head injury.	In all cases, the sensitivity of fluid-attenuated inversion-recovery images to equal or superior to that of conventional spin-echo images to the traumatic lesions. In 9 cases, central DAI of the fornix and corpus callosum could be seen only on sagittal fluid-attenuated inversion-recovery images.	2
33. Lang DA, Hadley DM, Teasdale GM, Macpherson P, Teasdale E. Gadolinium DTPA enhanced magnetic resonance imaging in acute head injury. <i>Acta Neurochir (Wien)</i> 1991; 109(1-2):5-11.	Review/Other-Dx	10 patients	To examine the effect of contrast enhancement on MRI in patients with a recent head injury.	Use of contrast did not increase the number of traumatic lesions identified and authors did not detect evidence of altered blood brain barrier permeability in any of the 7 patients, who had a total of 27 lesions, imaged between one and 4 days after injury. Enhancement was found in each of 3 patients imaged 6 or more days after injury. Findings suggest that traumatic cortical and intraparenchymal lesions are not associated with increased cerebrovascular permeability within the first 96 hours of a head injury.	4
34. Gentry LR. Imaging of closed head injury. <i>Radiology</i> 1994; 191(1):1-17.	Review/Other-Dx	N/A	Review current status of diagnostic imaging for patients with TBI. Emphasis of review is on MRI.	Good arguments for MRI within first 2 weeks after trauma; also possibly for neurologically stable acute head injury.	4
35. Gentry LR, Godersky JC, Thompson B. MR imaging of head trauma: review of the distribution and radiopathologic features of traumatic lesions. <i>AJR</i> 1988; 150(3):663-672.	Observational-Dx	40 patients	To determine the ability of MRI to prospectively identify and characterize the traumatic intraaxial lesions found in patients with closed head trauma by using a simple anatomic and topographic method of classification. MRI and CT were compared.	Primary intraaxial lesions were classified according to their distinctive topographical distribution within the brain and were of four main types: 1) DAI (48.2%), 2) cortical contusion (43.7%), 3) subcortical gray-matter injury (4.5%), and 4) primary brainstem injury (3.6%). MRI was found to be superior to CT and to be very effective in the detection of traumatic head lesions and some secondary forms of injury. While T2-weighted images were most useful for lesion detection, T1-weighted images proved to be most useful for anatomic localization and classification.	3
36. Gentry LR, Thompson B, Godersky JC. Trauma to the corpus callosum: MR features. <i>AJNR</i> 1988; 9(6):1129-1138.	Observational-Dx	78 total patients	Prospective study where MRI is compared with CT for detection of corpus callosum lesions after trauma in patients with acute (n = 63) and chronic (n = 15) head injuries.	MRI was significantly (P<.001) more sensitive than CT in the detection of callosal injuries. MRI and CT visualized 100% and 27%, respectively, of the traumatic callosal lesions that were detected in the study population.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
37. Arfanakis K, Haughton VM, Carew JD, Rogers BP, Dempsey RJ, Meyerand ME. Diffusion tensor MR imaging in diffuse axonal injury. <i>AJNR</i> 2002; 23(5):794-802.	Observational-Dx	5 patients; 10 controls	To determine the role of diffusion tensor imaging in depiction of DAI. White matter regions that appeared normal on CT and other MRI were studied, including apparent diffusion coefficient maps.	Patients displayed significant reduction of diffusion anisotropy in several regions compared with the homologous ones in the contralateral hemisphere. Such differences were not observed in the control subjects. Significant reduction of diffusion anisotropy was also detected when diffusion tensor results from the patients were compared with those of the controls. This reduction was often less evident 1 month after injury. White matter regions with reduced anisotropy are detected in the first 24 hours after TBI. Therefore, diffusion tensor imaging may be a powerful technique for in vivo detection of DAI.	3
38. Doezema D, King JN, Tandberg D, Espinosa MC, Orrison WW. Magnetic resonance imaging in minor head injury. <i>Ann Emerg Med</i> 1991; 20(12):1281-1285.	Observational-Dx	58 patients; 2 blinded reviewers	Prospective blinded cohort study to investigate the role of cranial MRI in evaluating patients discharged from the emergency department after MHI.	Fisher's exact test was used to compare symptoms in patients with abnormal and normal MRI scans. There was no significant difference in symptoms between patients with abnormal and those with normal scans ($P > .10$). The proportion of abnormal MRI scans was analyzed using the binomial distribution. 6/58 patients (10.3%) had traumatic intracranial abnormalities (proportion, 0.103; SD, 0.04; 95% CI, 0.04-0.21). Three had cortical contusions, and three had small subdural hematomas. Two of the six patients with abnormal MRI scans, both with small subdural hematomas, had normal CT scans. 10% of patients discharged from the emergency department after MHI had abnormal ultra-low-field cranial MRI scans. Additional research is needed to establish the clinical importance of this unexpected observation.	1
39. Skandsen T, Kvistad KA, Solheim O, Strand IH, Folvik M, Vik A. Prevalence and impact of diffuse axonal injury in patients with moderate and severe head injury: a cohort study of early magnetic resonance imaging findings and 1-year outcome. <i>J Neurosurg</i> 2010; 113(3):556-563.	Observational-Dx	159 patients	Prospective cohort study in which patients with moderate to severe head injuries using MRI in the early phase were examined. The objective was to explore the occurrence of DAI and determine whether DAI was related to level of consciousness and patient outcome.	DAI was found in almost three-quarters of the patients with moderate and severe head injury who survived the acute phase. DAI influenced the level of consciousness, and only in patients with DAI was GCS score related to outcome. Finally, DAI was a negative prognostic sign only when located in the brainstem.	2

Head Trauma EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
40. Rugg-Gunn FJ, Symms MR, Barker GJ, Greenwood R, Duncan JS. Diffusion imaging shows abnormalities after blunt head trauma when conventional magnetic resonance imaging is normal. <i>J Neurol Neurosurg Psychiatry</i> 2001; 70(4):530-533.	Observational-Dx	2 patients	Diffusion tensor imaging vs conventional MRI in head trauma.	Diffusion tensor imaging revealed abnormalities not apparent on MRI in 2 cases. Diffusion tensor imaging is a useful quantitative imaging method after head injury, and is more sensitive than conventional MRI.	3
41. Smith DH, Meaney DF, Lenkinski RE, et al. New magnetic resonance imaging techniques for the evaluation of traumatic brain injury. <i>J Neurotrauma</i> 1995; 12(4):573-577.	Review/Other-Dx	N/A	Review role of new MRI techniques in TBI.	Magnetization transfer imaging and diffusion weighted imaging are promising in depiction of TBI.	4
42. Wintermark M, Chiolero R, van Melle G, et al. Relationship between brain perfusion computed tomography variables and cerebral perfusion pressure in severe head trauma patients. <i>Crit Care Med</i> 2004; 32(7):1579-1587.	Observational-Dx	61 patients	Prospective cohort study to compare brain perfusion-CT results with invasive cerebral perfusion pressure monitoring in severe head trauma patients. The functional outcome of the 61 patients was evaluated 3 months after trauma on the basis of the GOS score and compared between groups using Fisher's exact tests.	Perfusion-CT helped distinguish between two groups of patients. Within each group, a significant correlation ($P < .001$) between the cerebral perfusion pressure values and the corresponding perfusion-CT results was demonstrated. There was also a significant correlation ($P < .001$) between the cerebral perfusion pressure values and the extent of the abnormal perfusion-CT areas (R up to .817). The first group was characterized by a weak dependence of perfusion-CT results on the corresponding cerebral perfusion pressure values (low slope) and the second group by a strong dependence (steep slope). These groups were interpreted as having preserved (or pseudo) and impaired cerebral vascular autoregulation, respectively. The functional outcome was better in the second group of patients. Intermittent perfusion-CT measurements plus continuous cerebral perfusion pressure measurement provide more information than continuous cerebral perfusion pressure alone. Perfusion-CT gives unique information regarding regional heterogeneity of brain perfusion. It might allow clinicians to distinguish between patients with preserved auto-regulation (or pseudoautoregulation) and those with impaired autoregulation and could therefore guide interpretation of cerebral perfusion pressure measurements and therapy.	3

Head Trauma EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
43. Brooks WM, Friedman SD, Gasparovic C. Magnetic resonance spectroscopy in traumatic brain injury. <i>J Head Trauma Rehabil</i> 2001; 16(2):149-164.	Review/Other-Dx	N/A	Review role of MRS in TBI.	MRS has potential to map metabolite changes throughout injury and recovery/rehabilitation.	4
44. Ichise M, Chung DG, Wang P, Wortzman G, Gray BG, Franks W. Technetium-99m-HMPAO SPECT, CT and MRI in the evaluation of patients with chronic traumatic brain injury: a correlation with neuropsychological performance. <i>J Nucl Med</i> 1994; 35(2):217-226.	Observational-Dx	29 patients (minor TBI, n=15 and major TBI, n=14); 17 controls	Purposes of study were: 1. to compare Tc-99m-HMPAO SPECT with CT and MRI in chronic TBI patients and 2. to correlate both functional and structural neuroimaging measurements of brain damage with neuropsychological performance.	19 (66%) patients showed 42 abnormalities on SPECT images, whereas 13 (45%) and 10 (34%) patients showed 29 abnormalities on MRI and 24 abnormalities on CT. SPECT detected relatively more abnormalities than CT or MRI in the minor TBI subgroup. The TBI group showed impairment on 11 tests for memory, attention and executive function. Of these, the anterior-posterior ratio correlated with six tests, whereas the ventricle-to-brain ratio, a known structural index of a poor neuropsychological outcome, correlated with only two tests. In evaluating chronic TBI patients, HMPAO SPECT, as a complement to CT or MRI, may play a useful role by demonstrating brain dysfunction in morphologically intact brain regions and providing objective evidence for some of the impaired neuropsychological performance.	2
45. Jacobs A, Put E, Ingels M, Bossuyt A. Prospective evaluation of technetium-99m-HMPAO SPECT in mild and moderate traumatic brain injury. <i>J Nucl Med</i> 1994; 35(6):942-947.	Observational-Dx	67 total patients; 42 - first subgroup of moderate trauma; 25 - second subgroup of mild trauma	Prospectively evaluate the contribution of Tc-99m-HMPAO SPECT in patients who have sustained acute, mild or moderate head trauma. All 67 patients underwent an initial SPECT within 4 weeks after a closed cranial trauma.	For the group as a whole (moderate trauma + mild trauma), the following results could be derived: in 32/33 initial SPECT negative cases, clinical symptoms had resolved; PPV of initial SPECT was only 20/34 (59%); the sensitivity for the repeat SPECT was 19/20 (95%). Results show that: 1) SPECT alterations correlate well with the severity of the trauma; 2) a negative initial SPECT study is a reliable predictor of a favorable clinical outcome; 3) in cases with a positive initial SPECT, a follow-up consisting of a combination of SPECT and clinical data is necessary; 4) in patients suffering from postconclusive symptoms, SPECT offers an instrument to objective sequelae.	2

Head Trauma EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
46. Jantzen KJ, Anderson B, Steinberg FL, Kelso JA. A prospective functional MR imaging study of mild traumatic brain injury in college football players. <i>AJNR</i> 2004; 25(5):738-745.	Observational-Dx	8 college football players; 4 with concussion and 4 without concussion (controls)	Prospective, functional neuroimaging approach was used to assess sports-related concussion in which imaging was performed before injury so that brain changes resulting from concussion could be better understood. Four players who had a concussion repeated baseline procedures within 1 week of injury. The remaining control players were retested at the end of the season.	Specific neural signatures of concussion were detected in individual players by comparing postconcussion results to preconcussion baseline values. The validity of these indicators was confirmed by comparing them with the same measures in noninjured control subjects. When compared with control subjects, concussed players had marked within-subject increases in the amplitude and extent of blood oxygen level-dependent activity during a finger-sequencing task. Effects were observed primarily in the parietal and lateral frontal and cerebellar regions. Differences in neural functioning were observed in the absence of observed deficits in behavioral performance, suggesting that this approach may increase sensitivity to concussion compared with neuropsychological evaluation alone. The proposed prospective neuroimaging approach may have great potential for understanding mild TBI and identifying mechanisms underlying recovery.	3
47. Kinuya K, Kakuda K, Nobata K, et al. Role of brain perfusion single-photon emission tomography in traumatic head injury. <i>Nucl Med Commun</i> 2004; 25(4):333-337.	Observational-Dx	35 patients	To examine the role of brain perfusion SPECT in traumatic head injury. Results were compared with those of X-ray CT and MRI.	CT and MRI detected brain contusions in 7 patients, subarachnoid haemorrhage in one patient and both in 9 patients. In 16 of the 17 subjects (94%), SPECT with Tc-99m-HMPAO revealed CT/MRI-negative abnormalities. SPECT afforded additional information in 26 patients (74%). CT possesses an advantage with respect to the detection of haemorrhagic lesions. MRI provides more precise information regarding contusions and axonal injury. Frequently, SPECT may be the only examination to reveal perfusion abnormalities which are related to symptoms in the absence of other objective findings, such as post-traumatic amnesia, vertigo or personality change.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Moritz CH, Rowley HA, Haughton VM, Swartz KR, Jones J, Badie B. Functional MR imaging assessment of a non-responsive brain injured patient. <i>Magn Reson Imaging</i> 2001; 19(8):1129-1132.	Review/Other-Dx	1	Case report is presented where functional MRI techniques are applied as a probe of brain function in a nonresponsive brain trauma patient with abnormal electrodiagnostic assessment.	Results demonstrated intact task-correlated sensory and cognitive blood oxygen level dependent hemodynamic response to stimuli. Electrodiagnostic studies were repeated and evoked potentials indicated supratentorial recovery in the cerebrum. At 3-months post trauma the patient had recovered many cognitive and sensorimotor functions, accurately reflecting the prognostic functional MRI evaluation. These results indicate that functional MRI examinations may provide a useful evaluation for brain function in nonresponsive brain trauma patients.	4
49. Metting Z, Rodiger LA, De Keyser J, van der Naalt J. Structural and functional neuroimaging in mild-to-moderate head injury. <i>Lancet Neurol</i> 2007; 6(8):699-710.	Review/Other-Dx	N/A	Review structural and functional imaging techniques in patients with mild-to-moderate head injury.	Review outlines the advantages and limitations of CT and MRI, including different MRI sequences, SPECT, perfusion-weighted MRI, perfusion CT, PET, MRS, functional MRI and magnetic encephalography in the contexts of the initial assessment and identification of brain abnormalities and the prediction of outcome.	4
50. Oder W, Goldenberg G, Podreka I, Deecke L. HM-PAO-SPECT in persistent vegetative state after head injury: prognostic indicator of the likelihood of recovery? <i>Intensive Care Med</i> 1991; 17(3):149-153.	Review/Other-Dx	12 consecutive patients	To determine role of SPECT early in rehab of head injury for prognosis of vegetative state.	A global reduction of cortical blood flow was a reliable predictor of poor long-term outcome, but the demonstration of only focal deficits did not reliably indicate a favorable outcome. Brain SPECT may help to improve outcome prediction in patients with traumatic persistent vegetative state.	4
51. Metting Z, Rodiger LA, Stewart RE, Oudkerk M, De Keyser J, van der Naalt J. Perfusion computed tomography in the acute phase of mild head injury: regional dysfunction and prognostic value. <i>Ann Neurol</i> 2009; 66(6):809-816.	Observational-Dx	76 patients; 25 healthy control subjects	To perform perfusion CT imaging in the acute phase of mild head injury in patients without intracranial abnormalities on the noncontrast CT, to assess whether these patients had cerebral perfusion abnormalities. Also, the relation between perfusion CT parameters and severity of head injury and outcome was evaluated.	In patients with a decreased GCS score, a significant decrease of cerebral blood flow and cerebral blood volume was detected in the frontal and occipital gray matter. In logistic regression analyses, decreased cerebral blood flow and cerebral blood volume in the frontal lobes predicted worse outcome according to the extended GOS score. CT perfusion parameters did not predict return to work. In the acute phase of mild head injury, disturbed cerebral perfusion is seen in patients with normal noncontrast CT correlating with severity of injury and outcome.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
52. Garnett MR, Blamire AM, Corkill RG, et al. Abnormal cerebral blood volume in regions of contused and normal appearing brain following traumatic brain injury using perfusion magnetic resonance imaging. <i>J Neurotrauma</i> 2001; 18(6):585-593.	Observational-Dx	18 patients	Conventional and perfusion MRI was used in patients, on average 10 days following injury, to assess possible subacute hemodynamic disturbances following TBI.	TBI is a heterogeneous insult causing a variety of pathology, not all of which is visible using conventional imaging methods. Regions of both normal appearing and contused brain may have an abnormal regional cerebral blood volume and alterations in regional cerebral blood volume may play a role in determining the clinical outcome of patients.	3
53. Govindaraju V, Gauger GE, Manley GT, Ebel A, Meeker M, Maudsley AA. Volumetric proton spectroscopic imaging of mild traumatic brain injury. <i>AJNR</i> 2004; 25(5):730-737.	Observational-Dx	14 patients with mild closed head injury; 13 control subjects	To obtain spectroscopic measurements over a large brain region to improve sensitivity for the characterization of the degree of injury. An additional aim was to evaluate the relationship of the MR spectroscopic findings with clinical outcomes 6 months after injury.	Significant changes ($P < .05$) were found for some, but not all, brain regions for the average values from all mild TBI subjects, with reduced NAA/total creatine, increased choline/creatine, and reduced NAA/choline. Global NAA/choline obtained from the sum of all sampled regions in two subjects was significantly reduced. Metabolite ratios were not significantly correlated with GCS score at admission or GOS score at 6 months after injury, although they were weakly correlated with GOS score at discharge.	3
54. Muttaqin Z, Uozumi T, Kuwabara S, et al. Hyperaemia prior to acute cerebral swelling in severe head injuries: the role of transcranial Doppler monitoring. <i>Acta Neurochir (Wien)</i> 1993; 123(1-2):76-81.	Observational-Dx	35 patients	To study TCD as predictor of outcome in head injury.	Patients who ended with severe disability, vegetative state, or death was 66% in this group of 9 patients, compared to only 34% for the 35 patients overall with severe head injury. Though the morbidity and mortality rates.	3
55. Steiger HJ, Aaslid R, Stooss R, Seiler RW. Transcranial Doppler monitoring in head injury: relations between type of injury, flow velocities, vasoreactivity, and outcome. <i>Neurosurgery</i> 1994; 34(1):79-85; discussion 85-76.	Review/Other-Dx	86 patients	Patients with head injuries with an admission GSC score between 3 and 12 were studied sequentially by transcranial and cervical Doppler sonography. On a subset of 26 patients, sequential autoregulation and CO ₂ reactivity testing was also performed. Patient characteristics and hemodynamic data were correlated and analyzed with respect to the final outcome.	The amount of subarachnoid hemorrhage on the initial CT correlated with the average middle cerebral artery/ICA flow velocity ratio ($r = 0.5$). Subarachnoid hemorrhages on CT and, to a lesser degree, subdural and intracerebral hematomas were correlated with an unfavorable outcome. Vasospasm remained subcritical, and no negative relationship to outcome could be identified. Hyperperfusion, as based on ICA flow velocities and vasospasm were correlated with diminished vasoreactivity. However, disturbed vasoreactivities, particularly during the first days, were common and did not necessarily predict an unfavorable outcome.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
56. van Santbrink H, Schouten JW, Steyerberg EW, Avezaat CJ, Maas AI. Serial transcranial Doppler measurements in traumatic brain injury with special focus on the early posttraumatic period. <i>Acta Neurochir (Wien)</i> 2002; 144(11):1141-1149.	Observational-Dx	57 patients	To determine the potential of transcranial Doppler to detect decreased blood flow velocity in the early phase after TBI. To determine whether flow velocity differs between hemispheres in patients with focal lesions vs those with more diffuse injuries. To determine if decreased blood flow velocity is indicative of cerebral ischemia, as evidenced by measurements of brain tissue pO(2).	A low flow velocity state was observed in 63% of patients studied. Decreased flow was most pronounced during the first 8 hours after injury and was accompanied by high pulsatility indices, especially at the side of the lesion. Flow velocity increased significantly after this time period. Initial Vmca values had a strong correlation with ipsilateral measured PbrO(2) values (R=0.73). The occurrence of a low flow velocity state was associated with poorer outcome (OR 3.9). TCD studies show reduction of cerebral blood flow velocity in the acute phase after TBI. Decreased flow velocity is most pronounced ipsilateral to focal pathology. A low flow velocity state is probably due to high peripheral resistance, and is indicative of ischemia, as demonstrated by the association with decreased PbrO(2). A low flow velocity state is of prognostic value and identifies patients at increased risk for ischemia. Early TCD studies are recommended in TBI.	3
57. American College of Radiology. <i>Manual on Contrast Media</i> . Available at: http://www.acr.org/~link.aspx?_id=29C40D1FE0EC4E5EAB6861BD213793E5&_z=z .	Review/Other-Dx	N/A	Guidance document on contrast media to assist radiologists in recognizing and managing risks associated with the use of contrast media.	N/A	4

Evidence Table Key

Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
 - a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
 - b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
 - c) the study is an expert opinion or consensus document.

Dx = Diagnostic

Tx = Treatment

Abbreviations Key

CI = Confidence interval
 CT = Computed tomography
 DAI = Diffuse axonal injury
 GCS = Glasgow Coma Scale
 GOS = Glasgow Outcome Scale
 HMPAO = Hexamethyl-propylamine-oxime
 ICA = Internal carotid artery
 MDCT = Multidetector computed tomography
 MHI = Minor head injury
 MRI = Magnetic resonance imaging
 MRS = Magnetic resonance spectroscopy
 NAA = N-acetylaspartate
 NPV = Negative predictive value
 OR = Odds ratio
 PET = Positron emission tomography
 PPV = Positive predictive value
 TBI = Traumatic brain injury
 TCD = Transcranial Doppler