Head Injury in Infants, Children and Adults: Triage, Assessment, Investigation and Early Management

National Collaborative Centre for Acute Care

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Chapter 1. Background and scope

1.1 Introduction

Hospital Episode Statistics data for the 2000/2001 annual dataset indicates that there were 112,978 admissions to hospitals in England with a primary diagnosis of head injury (ICD10 codes S00-S09). Seventy-two per cent of these were male admissions and 30% were children under 15 years of age. Extrapolating on the basis of relative population size gives an estimate of a further 6,700 head injury admissions in Wales. There are no reliable up to date figures for the total denominator of attenders with a head injury at Accident and Emergency (A&E) Departments. A figure of one million A&E attenders for the United Kingdom as a whole is often quoted but this is based on figures from the late 1970s. It is estimated that head injury admissions represent around 20% of all head injury attenders, which would imply around 600,000 patients per annum attending A&E in England and Wales with a head injury. The true A&E attendance rate may be closer to 700,000 patients however, as it is likely that the proportion of head injured patients admitted to hospital has fallen below 20% in recent years. The poor quality of information regarding head injury attenders should improve as the use of a common A&E dataset increases.

The number of patients who undergo neurosurgery each year following a head injury is also unclear. A figure of around 4,000 patients per year for the UK as a whole has been quoted, but this may be slightly higher than is the case. Hospital Episode Statistics data for the 2000/2001 annual dataset indicates that 398 patients in England underwent an operation to drain the extradural space (OPCS code A40) and 2,048 patients underwent an operation to drain the subdural space (OPCS code A41). These figures do not include a small number of other neurosurgical procedures possible after head injury, and include some patients with a non-head injury diagnosis. Thus, the routine data available does not allow for a precise estimate of neurosurgical volume after head injury for England and Wales, but points to a figure in the low thousands.

Although incidence is high, the mortality rate from head injury is low (6-10 per 100,000). As few as 0.2% of all people attending A&E with a head injury will suffer a fatal outcome from their head injury. Ninety per cent of all patients will present with a minor or mild head injury (Glasgow Coma Scale [GCS] > 12) but the majority of fatal outcomes will be in the moderate (GCS 9-12) or severe (GCS ≤ 8) head injury groups which account for only 10% of attenders. Therefore A&E Departments are required to see a large number of patients with a minor/mild head injury, and identify the very small number of these that will go on to have serious intracranial complications.

1.2 UK Guidelines

The first UK-wide guidelines on identifying high-risk head injured patients were drawn up by a Working Party of Neurosurgeons in 1984. They were used in the UK for over fifteen years and relied on various clinical factors, particularly the level of...
consciousness to triage patients into different risk categories. The main investigation incorporate into these guidelines was skull radiography (SXR), reflecting the perceived importance of skull fracture as a risk factor for intracranial complications. Modifications to this guideline have since been published by the Society of British Neurological Surgeons, the Royal College of Surgeons of England (RCS) in 1999 and by the Scottish Intercollegiate Guidelines Network (SIGN) in 2000. The triage and imaging of head injured patients is also addressed by guidelines from the Royal College of Radiologists.

The new UK guidelines centre around the identification of patients with a high (e.g. over 10%) risk of intracranial injury for computed tomography (CT) scanning, using the GCS, the presence of a skull fracture and various other clinical variables. Admission for observation is still considered a key tool for medium-risk patients.

1.3 Role of CT imaging

There is evidence of an increased desire to perform CT scanning in the UK. UK Hospitals have seen a marked increase in the number of CT scans being requested and over the last five years the number of CT scans being requested for head injury has doubled in District General Hospitals (Yates DW, personal communication, 2002). This change was to some extent reflected in the 1999 RCS guidelines and 2000 SIGN guidelines, which recommended a more liberal CT scanning policy, while still adhering to the SXR as the first line investigation in the majority of minor/mild head injuries. The move to CT reflects a general consensus that earlier definitive imaging is associated with improved outcomes.

1.4 North American guidelines

While the UK continues to use level of consciousness and SXR as the primary triage tools, with observation for medium risk patients and CT for the highest risk groups, these methods are now rarely used in North America. In the USA, CT scanning is performed in between 75% to 100% of all patients with normal GCS and loss of consciousness. This is in marked contrast to CT scan rates in the UK that are in the order of 2-12% of all patients attending the A&E Department with a head injury.

In the UK, controversy over guidelines in head injuries centres on whether increased CT scanning is feasible or advisable, but in the USA the discussion is exactly the reverse. Research is directed towards attempts to reduce the very large numbers of CT scans being performed.

1.5 The skull radiograph

Historically, in the absence of readily available CT scanning resources, SXR has been used to triage patients with minor/mild head injuries into high and low risk groups. In the UK up to 74% of all patients attending A&E with a head injury receive a SXR, even though the image may reveal a fracture in only 2% of cases.
An elevation of risk following positive SXR is widely acknowledged and supported by UK evidence.\textsuperscript{14} A meta-analysis of thirteen studies where at least 50% of patients underwent CT, containing almost 13,000 patients with a weighted mean prevalence of intracranial haemorrhage 0.083 (95% CIs: 0.03-0.13), found that the sensitivity and specificity of a SXR for predicting the presence of intracranial pathology were 38% and 95% respectively.\textsuperscript{20} The equivalent predictive values were 0.41 (positive predictive value) and 0.94 (negative predictive value). These figures imply that if there is a skull fracture diagnosed on radiography, the risk of an intracranial haemorrhage is elevated (about 4.9 times higher than before testing) but we cannot rule out an intracranial haemorrhage in patients for whom a SXR does not show a skull fracture.

One reason for the low sensitivity of SXR in predicting an intracranial haemorrhage is the reliability of radiographic interpretation. It has been consistently shown that clinically competent A&E clinicians will miss between 13% and 23% of all skull fractures when interpreting the radiograph.\textsuperscript{17,24,25}

As CT scanning (carried out at an appropriate time post-injury) has both sensitivities and specificities approaching 100%, CT is superior as the primary investigation. The relatively low ordering rate for CT in the UK has historically been a function of availability. However, there has been a substantial investment in CT scanners in England and Wales over the last decade, increasing the capacity of modern scanners within the NHS considerably. In addition, CT technology has advanced considerably in recent years (e.g. multisection helical CT), improving the imaging output and reducing radiation exposure. The new scanners have greatly reduced the need for general anaesthesia and reduced the sedation rate in infants and other uncooperative patients.\textsuperscript{26,27}

1.6 Admission

Acute head injury admissions account for 320,900 bed days in hospitals in England (plus a further 19,000 in Wales by population extrapolation) representing 0.64% of all NHS bed days.\textsuperscript{1} This represents a significant resource burden on the NHS. However only 1-3% of admitted patients actually go on to develop life-threatening intracranial pathology, with the remainder going home within 48 hours, having had no intervention other than observation.\textsuperscript{6,7,17}

Also of concern is the quality of the observation that patients receive while in hospital. In a recent retrospective survey of 200,000 children in the North-East of England, only 14 children who presented with a minor head injury required neurosurgery. However, the recognition of secondary deterioration was delayed in all 14 patients, with documented routine neurological observations in only one child. Diagnosis of an intracranial haematoma was made between six hours and 14 days after the head injury, with a median delay of 18 hours.\textsuperscript{28}

This is not a problem unique to the UK as in the USA it has been found that only 50% of patients admitted with a minor head injury had documentation of neurological observations and for the majority of these, the frequency of observations was not sufficient to detect early neurological deterioration.\textsuperscript{29} In the UK head injured patients
have historically been observed on non-specialist wards by nurses and doctors not experienced in neurological observation. In 1999 The Royal College of Surgeons of England surveyed General Surgeons in the UK and found that although 56% of Consultants observed head injured patients on their wards, only 48% had any neurological experience and 34% were dissatisfied with this referral process. The Royal College advised that head injured patients should not be observed in non-specialist wards, but it is unclear whether this has resulted in an increased proportion of head injured patients being observed in A&E Department wards.

1.7 Morbidity

The incidence of morbidity after head injury is higher than had been previously appreciated and far exceeds the capacity of UK neurorehabilitation services. In a study of head injury admissions in 1995/96 in Glasgow, 47% of patients followed up for one year after discharge had survived with some form of disability. Surprisingly, the proportion of patients suffering the most serious (i.e. moderate or severe) disabilities, did not vary according to the severity of the initial injury. The study found that 47% of patients admitted with apparently minor/mild head injuries suffered significant disabilities, compared to 45% of moderate head injured patients, and 48% of severely head injured patients. Only 47% of disabled survivors were seen in hospital after discharge and only 28% received some input from rehabilitation services. A second large UK study set up a minor head injury clinic. They saw 639 patients who had originally had a minor head injury. Fifty-six per cent were not back to work at two weeks, and 12% had not returned to work at 6 weeks. In addition at six weeks many had persisting symptoms including headache (13%), memory loss (15%) and concentration problems (14%). This data has been reproduced in other countries.

1.8 Cause of injury

In the UK 70-88% of all head injuries are male, 10-19% are aged ≥ 65 years and 40-50% are children. Falls are the most common cause of a minor head injury, usually accounting for 22-43% of injuries, followed by road traffic accidents (~25%) and assaults (30-50%). Alcohol may be involved in up to 65% of adult head injuries. Of note, road traffic accidents account for a far greater proportion of moderate to severe head injuries. Also there are marked regional variations, especially in assaults and alcohol use, but the incidence of penetrating head trauma remains low. The prevalence of death due to head injury in the UK is 6-10 per 100,000.

In the USA 65-75% of head injured patients are male. The USA has a higher rate of road traffic accidents (~50%) and a lower rate of falls (20%-30%) than the UK, reflecting the difference in car usage in the two countries. Assaults account for around 20% of injuries although again there are regional differences. Alcohol is associated with around 50% of all adult head injuries, either by the patients or the person causing the incident. Firearms trauma to the head surpassed motor vehicles as the single largest cause of death from traumatic head injury in 1990 in the USA. However, gunshot trauma to the head is not a common cause for attendance to hospital. This is largely due to the fact that 90% of gunshot wounds to the head are fatal and that two-thirds of these patients will not reach hospital. The prevalence of
death due to any traumatic head injury is 20 per 100,000 in the USA, which is double the rate in the UK. Firearm-related deaths accounts for 8 per 100,000 of these deaths.\textsuperscript{15,19,35-38}

Comparisons with a Canadian population are important at this stage because of the importance of Canadian evidence to these guidelines. A large Canadian study on head injured patients with GCS > 12 found that 31\% of patients had suffered falls, comparable with UK estimates. However, the Canadian study found that 43\% had been in some form of road traffic accidents, which is higher than the estimate of 25\% for the UK. Assaults, by contrast, accounted for only 11\% of the Canadian sample, compared to estimates of 30-50\% for the UK. A similar proportion of the sample were male (69\%).\textsuperscript{21} The GDG is also of the opinion that the UK acute head injured population are more likely to have a history of alcohol involvement.

1.9 Summary of current care in the UK

For 15 years, the UK has followed guidelines for minor/mild head injuries based on consciousness level, with SXR as the primary investigation, and admission for observation of most patients considered to be at risk for intracranial complications. CT scanning is generally reserved for patients with moderate or severe head injuries (GCS < 13). CT scanning of head injured patients has gradually increased in recent years. Compared to North America however, markedly different protocols are still being followed in the UK. This is largely due to a historically lower availability of CT scanning resources in the UK and the consequent need to rely on SXR as a triage tool.

Only 1-3\% of head injured patients who are admitted to hospital in the UK for observation will go on to require neurosurgery, with the remainder being discharged. Even a small reduction in the proportion of patients requiring admission would have a greatly beneficial impact on hospital resources.

There is evidence that outcomes for severely head injured patients in England and Wales, as measured by severity adjusted odds of death, improved steadily up to the mid-1990s, but have stagnated since. There is also indirect evidence that trauma care for severely head injured patients in England and Wales is not delivering the same proportion of expected survivors as trauma care in the United States, although this data is confounded by case mix issues, especially the older age profile of head injured patients in England and Wales.\textsuperscript{39}

A major source of concern is the shortage of emergency neurosurgical beds in the UK. A recent survey revealed only 43 neurosurgical intensive care beds available for an overall estimated population of 63.6 million.\textsuperscript{40} This shortfall can lead to delays in patient transfer, and is symptomatic of larger resource and workload issues for neurosurgery in the UK.\textsuperscript{41} These larger resource problems have many implications for head injury care, including delays obtaining a neurosurgical opinion at night, or at the weekends.

Finally there is increasing awareness of a large level of disability following minor/mild head injury. The provision of services to identify and treat these patients may bring
great benefits to patients who would otherwise spend prolonged periods off work or dependent on relatives. Unfortunately, neurorehabilitation services in England and Wales are under-resourced and do not have the capacity to provide the volume of services currently required.

1.10 Scope

The National Institute for Clinical Excellence (NICE) commissioned the National Collaborative Centre for Acute Care (NCCAC) to produce a clinical guideline for patients and clinicians on the early management of head injury. The guideline provides advice on effective care using the best possible research evidence. The project began in December 2001 based on a scope and commissioning brief received from NICE. These documents reflected a NICE consultation with relevant stakeholders. The clinical questions outlined in the scope were as follows:

- pre-hospital management including assessment, airway management and ventilation, cervical spine (c-spine) protection and appropriate transfer;
- indications for referral to hospital from pre-hospital care;
- secondary care with the aim of early detection of intracranial complications, including admission for observation, SXR and other imaging procedures, including CT scanning and nuclear magnetic resonance;
- criteria for transfer and discharge including circumstances when patients should be admitted to a neurosurgical unit, admitted for a short period or discharged home;
- criteria for surgical intervention;
- information for patients and their carer/s prior to and during hospital admission;
- management at home of patients who are discharged within 48 hours of admission including advice to primary care and A&E staff on the management of patients who re-present with suspicious symptoms;
- guidance on appropriate handover arrangements;
- information for patients and carers.

1.10.1 Population

The guideline offers best practice on the care of all patients who present with a suspected or confirmed traumatic head injury with or without other major trauma. Separate advice is provided for adults and children (including infants) where different practices are indicated. It offers advice on the management of patients with a suspected or confirmed head injury who may be unaware that they have sustained a head injury because of intoxication or other causes. The guideline does not provide advice on the management of patients with other traumatic injury to the head (e.g. to the eye or face). It does not address the rehabilitation of long term care of patients with a head injury but the guideline does explore possible criteria for the early identification of patients who require rehabilitation.

1.10.2 Health care setting
The guideline covers the care received from NHS advice sources (e.g. NHS Direct, A&E helplines) primary care, ambulance, and hospital staff who have direct contact with and make decisions concerning the care of patients who present with suspected or confirmed head injury. It recognises the need for care to be integrated between the primary, secondary and tertiary sectors, and the need to ensure that none of these sectors is unnecessarily overburdened. It addresses the management of patients in primary care, pre-hospital, in A&E or similar units, and in the different hospital settings to which they may be transferred where observation for possible deterioration is indicated.

The guideline does not address management within the intensive care or neurosurgical unit, but provides guidance on the appropriate circumstances in which to request a neurosurgical opinion.

Service configuration, competencies, skill mix and training requirements of staff are outside the scope of the guidelines, as they are the remit of the NHS Modernisation Agency but good practice points on these matters are introduced in places.
Chapter 2. Methods

2.1 Guideline development group

A Guideline Development Group (GDG) representing all relevant professional and patient parties was formed in December 2001, under the Chairmanship of Professor David Yates from the Trauma Audit and Research Network. GDG meetings were held on the following dates:

- January 23rd 2002
- March 14th 2002
- May 2nd 2002
- June 6th 2002
- July 25th 2002
- September 11th 2002

2.2 Working principles

At the outset it was recognised that a full systematic review for all areas in the scope received from NICE could not be performed in the time available. It was decided therefore to focus the full systematic reviewing methods on the selection of patients for imaging of the head and c-spine, given that these issues are at the heart of acute management of head injuries. It was agreed that brief literature reviews and formal consensus methods would be used to deal with the remaining topics.

For the purposes of the guidelines it was agreed that infants are aged < 2 years, children are 2-15 year olds and adults are aged 16 years or more. 'Head injury' for the purposes of the guidelines is defined as any trauma to the head, other than superficial injuries to the face.

It was also agreed that the primary outcome of concern throughout the guideline development process would be defined as 'clinically important brain injury' as demonstrated by imaging of the head. It was agreed that need for neurosurgery was too limited a definition, given that the guideline scope calls for some means for the early identification of those patients that might benefit from neurorehabilitation.

2.2.1 Glasgow Coma Scale

It was agreed that the assessment and classification of patients should be guided primarily by the adult and paediatric versions of the Glasgow Coma Scale and its derivative the Glasgow Coma Score. Good practice in the use of the Glasgow Coma Scale and Score should be adhered to at all times.

- Monitoring and exchange of information about individual patients should be based on three separate responses on the GCS (e.g. a patient scoring 13 based on scores of 4 on eye-opening, 4 on verbal response and 5 on motor response should be communicated as E4,V4,M5);
• If a total score is recorded or communicated, it should be based on a sum of 15, and to avoid confusion this denominator should be specified (e.g., 13/15);
• The paediatric version of the GCS should include a ‘grimace’ alternative to the verbal score to facilitate scoring in pre-verbal or intubated patients;4
• Best practice in paediatric coma observation and recording as detailed by the National Paediatric Neuroscience Benchmarking Group should be followed at all times.5

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

2.3 Systematic reviews

The systematic reviews performed for these guidelines were designed to identify different types of clinical decision rule. The studies reviewed included derivation designs (usually cohort studies where the predictive power of a number of prognostic variables were explored) and validation designs (where the sensitivity and specificity of previously defined rules were examined). Data collection may have been prospective or retrospective data. The follow-up rate for important outcomes was also recorded: a standard of at least 80% follow-up is often stated for studies on the development of clinical decision rules. The use of multivariate statistics to identify the independent contribution of each variable to the rules was also an important determinant of study quality.

The GDG agreed to use the following classification, taken from the Oxford Centre for Evidence-based Medicine Levels of Evidence (May 2001), to summarise the evidence levels for studies on the development of clinical decision rules:

1. Cohort study with consecutive patients and good reference standards, used to validate clinical decision rules;
2. Cohort study with consecutive patients and good reference standards used to derive clinical decision rules;
3. Non-consecutive study or without consistently applied reference standards;
4. Case-control study, poor or non-independent reference standard;
5. Expert opinion without explicit critical appraisal, or based on physiology, bench research or “first principles”.

It was also agreed to adopt the Oxford Centre for Evidence-based Medicine Levels of Evidence grade of recommendation (May 2001) as follows:

A Consistent level 1 studies
B Consistent level 2 or 3 studies or extrapolations from level 1 studies
C Level 4 studies or extrapolations from level 2 or 3 studies
D Level 5 evidence or troublingly inconsistent or inconclusive studies of any level

2.4 Resources

The following databases were searched for literature for the period 1990 to 2002:
• Medline
• Embase
• The Cochrane Library – this includes:
  • Cochrane Database of Systematic Reviews (CDSR)
  • Database of Abstracts of Reviews of Effectiveness (DARE)
  • Cochrane Controlled Trials Register (CCTR)
  • Health Technology Assessment (HTA) Database
  • NHS Economic Evaluations Database (NHS-EED)
  • System for Information on Grey Literature in Europe (SIGLE)
  • Health Management Information Consortium (HMIC)

In addition, reference lists of previous guidelines and key papers were used to identify other key references, including pre-1990 literature. Experts were contacted to identify other key literature. Grey literature was identified using NICE stakeholder contacts. The following web sites were also searched:

• Agency for Healthcare Research and Quality (AHRQ)
• Brain Trauma Foundation
• CMA Infobase – clinical practice guidelines
• Department of Health
• http://www.google.com
• National Guideline Clearing House (USA)
• National Research Register (NRR)
• Organising Medical Networked Information (OMNI)
• Scottish Intercollegiate Guideline Network (SIGN)
• Turning Research into Practice (TRIP) Database

No useful additional papers (i.e. in addition to the grey literature already in our position and the documents found during the database searches) were found using these methods, apart from a small number of documents of interest to the systematic review on radiation risks and CT of the head.

2.5 Consensus methods

Formal consensus methods were used to generate agreement regarding the recommendations for these guidelines. Consensus was used for all grades of recommendation, even those based on level one evidence, to ensure complete ‘sign-up’ by all GDG members to the final guidelines. An initial set of 67 recommendations was circulated in questionnaire format, and GDG members rated their agreement with each recommendation on a nine point scale (strongly disagree to strongly agree). Separate ratings were made where relevant for infants, children and adults. A meeting was then held on July 25th 2002 to discuss the recommendations in the light of GDG responses to the questionnaire. A revised set of 56 recommendations was drawn up following the meeting and again circulated to GDG members for their appraisal. At this stage there was near complete agreement with all recommendations, and only minor revisions in wording were required. The
recommendations presented in this guideline are the result of the consensus exercise.

2.6 Systematic review of indications for CT of the head

This systematic review aimed to identify highly sensitive and specific clinical decision rules which could be used to select patients who are at high risk of clinically important brain injury, and who therefore should have immediate CT imaging of the head.

This search produced 1454 abstracts in MEDLINE and 680 abstracts in EMBASE (after duplicates with MEDLINE were excluded). An initial screen for relevance was carried out by one systematic reviewer, which reduced the number of abstracts to 174 in MEDLINE and 68 in EMBASE. These abstracts were then independently read by two reviewers to identify those papers that should be obtained and read in full. At this point the only criteria used was the likelihood that the paper described a rule for the diagnosis of intracranial haematoma (ICH), clinically important brain injury or need for a neurosurgical intervention in recently head injured patients, and produced some data on the likely sensitivity and specificity of the rule. We were interested in both derivation and validation papers.

The independent reviewing process produced 72 papers in MEDLINE and 20 papers in EMBASE. In total 92 papers were deemed worthy of a full review.

A brief description of the rule proposed was extracted. Many papers do not provide explicit description of the diagnostic strategies, inclusion criteria, or post-diagnosis management strategies (e.g. eligibility for early discharge). The participant descriptions extracted were GCS levels, age, prevalence of important outcomes (especially intracranial haemorrhage) and the main inclusion and exclusion criteria. If non-consecutive patients (e.g. CT patients only where 100% CT was not the rule) this was noted. The outcomes extracted included the need for neurosurgery, ICH, intracranial injury and clinically important brain injury and CT ordering rate. Data on specificity and sensitivity were recorded where possible; 95% confidence intervals were also recorded or calculated if possible.

2.7 Systematic review of indications for imaging of the cervical spine

The systematic review aimed to identify clinical decision rules which could be used to select patients who are at high risk of clinically important c-spine fracture, and who therefore should have three view plain radiography followed by other imaging if these prove inadequate.

This search produced 863 abstracts in MEDLINE and 268 in EMBASE (after duplicates had been removed). An initial screen for relevance was carried out by one systematic reviewer, which reduced the number of abstracts to 142 papers in MEDLINE and 10 papers in EMBASE. These abstracts were then independently read by two reviewers to identify those papers that should be obtained and read in full. At this point the only criteria used was the likelihood that the paper described a rule for the diagnosis of cervical fracture, and produced some data on the likely
sensitivity and specificity of the rule. We were interested in both derivation and validation papers.

The independent reviewing process produced 78 papers in MEDLINE and 7 papers in EMBASE. In total 85 papers were deemed worthy of a full review.

A brief description of the rule proposed was extracted. Many papers did not provide an explicit description of the diagnostic strategies, inclusion criteria, or post-diagnosis management strategies (e.g. eligibility for early discharge).

Participant details extracted included patient symptom status, alertness, age, number of centres, prevalence of important outcomes, the country of study and the main inclusion and exclusion criteria. The outcomes that the rule is intended to detect were noted. These included, clinically important cervical fracture, unimportant c-spine fracture, need for surgery and internal or external fixation. The radiography ordering rate was also noted as an outcome. Data on specificity and sensitivity were recorded where possible; 95% confidence intervals were also recorded or calculated if possible.

2.8 Systematic review of means of identifying patients at high risk of late sequelae

This systematic review aimed to identify clinical decision rules that could be used to select patients who are at high risk of late sequelae, and who therefore should be followed up so that potential long-term problems can be identified.

The original search for CT algorithms for the identification of prognostic variables for intracranial haematoma produced 1454 abstracts in MEDLINE and 680 abstracts in EMBASE (after duplicates with MEDLINE were excluded). This full abstract list was reviewed to look for papers that may be of relevance to disability. After this a search was performed on Medline and Embase, listed in Appendix 1 for prognosis of minor/mild head injury. Experts were also contacted for relevant papers. The search of the 1454 abstracts revealed 152 potentially interesting papers. The additional MEDLINE and EMBASE search revealed 48 papers not previously seen of which eight abstracts looked to be of relevance. Experts provided three useful papers. These abstracts were then independently read by two reviewers to identify those papers that should be obtained and read in full. At this point the only criteria used was the likelihood that the paper may describe a rule or provide factors in the acute assessment of the patient that may predict post-concussional syndrome. After this assessment 25 papers were selected for full review

A brief description of the rule proposed was extracted. Only one paper actually proposed a rule. Participant description focused on GCS levels, age, and the main inclusion and exclusion criteria. The outcome measures used were extracted. The definitions of long-term disability or post-concussive were heterogeneous. Data on specificity and sensitivity were recorded where possible. As only one paper provided a rule, these figures could only be calculated for one paper. The prevalence of important outcomes was also recorded. A previous systematic review was also available to the project team and this informed the review.
2.9 Systematic review of medical radiation risks

This review aimed to provide simple estimates of the radiation risks associated with CT of the head. The search produced 654 abstracts in MEDLINE and 260 in EMBASE (after duplicates had been removed). A search using the Google search engine revealed useful documents from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the National Radiological Protection Board (NRPB). Personal communications with the National Radiological Protection Board also provided papers and data which contributed to the review. Following abstract review and including the papers supplied by experts, 80 full articles were obtained and were reviewed to determine relevance. This left 15 documents considered of relevance and these contributed to the text of this guideline.
Chapter 3. Pre-hospital advice and referral to hospital

3.1 Predictor variables

A large number of people suffer head injuries each year, many of which are minor enough to not require medical attention. Advice to the public and community services should focus on the variables known to elevate the risk of clinically important brain injury or another head wound that may require surgical repair. A large number of variables have been identified as elevating the risk of these outcomes after head injury.

3.1.1 Glasgow Coma Scale score

It is well established that the risk of intracranial complications, and of subsequent need for surgery increases as GCS score declines.\(^1,2\) A recent study estimated the risk to increase from 4.8\% (for clinically important brain injury) with an initial GCS = 15, to 17.2\% for GCS = 14, and to 40.9\% for GCS = 13.\(^3\) A further study on paediatric head injury found that a GCS < 13 was a significant predictor of an abnormal CT scan in children with head injury aged 14 years or younger.\(^4\)

3.1.2 Loss of consciousness

A history of altered consciousness after a head injury increases the risk of intracranial complications although the absolute risk remains low.\(^1,2\) There is controversy regarding the importance of momentary loss of consciousness, and the variable is by definition difficult to measure when no independent observer is available. There is evidence that intracranial complications can occur even when no loss of consciousness has occurred, but the vast majority of studies in this area specify loss of consciousness as a patient inclusion criteria resulting in a paucity of literature on this aspect of risk.

3.1.3 Amnesia

Amnesia after head injury increases the risk of intracranial complications, although again the length of post-traumatic amnesia is controversial.\(^1,2\) Amnesia is usually defined as post-traumatic in the literature but a recent important study has suggested that retrograde (i.e. for memories before the incident) amnesia is also an important risk factor.\(^3\) Amnesia is a less useful predictor variable in infants and young children, simply because it is difficult to measure.

3.1.4 Neurological signs

Post-traumatic neurological signs such as focal neurological deficits or seizure are highly associated with the risk of an intracranial complication\(^2\) and the risk is so large that these patients are commonly excluded from studies developing clinical decision rules for the management of acute head injury.

3.1.5 Bleeding disorders and use of anticoagulants
Patients with coagulopathy have an elevated risk of intracranial complications but the exact strength of this relationship has not been established.3,5,6

3.1.6 Skull fracture

It is accepted that the risk of intracranial complications is higher in patients with a diagnosis of skull fracture. It can be estimated that the risk of developing an intracranial haematoma is about 12 times higher in patients with a radiographically detected skull fracture than in patients without, based on an estimate of 38% sensitivity and 95% specificity produced by a meta-analysis of the value of the radiological diagnosis of skull fracture. There is variation in diagnostic practice for skull fracture. Some guidelines advocate the use of SXR in the diagnosis of skull fracture,8 while others advocate the use of signs alone (e.g. CSF leak, periorbital haematoma, depressed or open skull injury, penetrating injury).3

3.1.7 Age

An exact age threshold for identifying high-risk patients has not been identified, but it is clear that increasing age is associated with an increased risk of intracranial complications and a poorer prognosis.9 Commonly used thresholds are 60 years10,11 and 65 years.3,9 To avoid confusion, the GDG chose to adopt a standard age threshold throughout these guidelines of ≥ 65 years. An odds ratio of 4.1 (95% CIs: 2.8-6.1) for clinically important brain injury has been quoted with this threshold, providing the patient aged ≥ 65 years had suffered loss of consciousness or post-traumatic amnesia.3

There is evidence that the prevalence of intracranial complications in children and infants is much lower than in adults.1 However, this must be weighed against the fact that an unknown, but significant proportion of head injuries in infants and young children are intentionally inflicted. These injuries may result in a different pattern of morbidity to that seen in adults, and obviously require investigation regardless of outcome.

3.1.8 Mechanism of injury

High energy injury mechanisms have an intuitive appeal in determining the risk of intracranial complications but there are difficulties with providing an exact definition of 'high energy'. Terms such as 'assault' or 'road traffic accident' cover a great heterogeneity of circumstance. A recent high quality study has proposed the following criteria as high risk factors for clinically important brain injuries after head injury: pedestrian struck by motor vehicle, occupant ejected from motor vehicle, or a fall from a height of greater than three feet or more than five stairs.3 A further study has defined 'axial load to head' as a high risk factor for c-spine injury after an accident.12 This covers the following areas: diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorized recreational vehicles; bicycle collision). In addition, there are many other high energy mechanism injuries which one cannot cover in an exhaustive list (e.g.
the variety of blunt instruments that could be used in a violent assault) which were considered to be important by the GDG.

3.1.9 Drug or alcohol intoxication

Drug or alcohol intoxication can result in signs and symptoms which are risk factors for intracranial complications (e.g. vomiting, headache, amnesia, impaired consciousness) but have also been identified as independent risk factors following head injury, making a differential diagnosis difficult. In addition, alcohol abuse can lead to hypoglycaemia, which can in turn lead to impaired consciousness. This may lead to the incorrect diagnosis of a developing intracranial trauma complication.

3.1.10 Headache

Headache is a controversial variable in the evaluation of risk for intracranial complications. In some studies the variable has been an important predictor but not in others. Headache can be difficult to define both in terms of duration and severity, particularly in infants and young children.

3.1.11 Vomiting

Vomiting is consistently identified as a high risk variable, but there is some controversy regarding the number of episodes required to qualify as high-risk. Vomiting is also quite common in children and infants and its predictive power is controversial in this age group.

3.1.12 Irritability and altered behaviour

Irritability and altered behaviour are catch-all terms which are sometimes used in clinical guidelines for acute head injury management with little empirical evidence. However, they may be an important sign in the pre-verbal child, where other problems like amnesia or headaches cannot be detected.

3.1.13 History of cranial neurosurgical interventions

Previous cranial neurosurgical interventions have an intuitive relationship with risk of intracranial complications and were considered by the GDG despite a dearth of empirical evidence on the variable.

3.2 Public health literature

Public health literature and other non-medical sources of advice (e.g. St John’s Ambulance, Police Officers) should encourage patients who have any concerns following a head injury to themselves or to another person, regardless of the injury severity, to seek immediate medical advice.

This is a grade D recommendation based on evidence level five.

3.3 Telephone advice lines and web sites
Telephone advice services and web sites (e.g. NHS Direct, A&E helplines) should refer patients who have suffered a head injury to the emergency ambulance services (i.e. 999) if they have suffered any of the following (alternative terms to facilitate communication are in parenthesis):

- any focal neurological deficit since the injury (examples include problems understanding, speaking, reading or writing; decreased sensation; loss of balance; general weakness; visual changes; abnormal reflexes; and problems walking)
- any suspicion of a skull fracture or penetrating head injury since the injury (e.g. clear fluid running from the ears or nose, black eye, penetrating injury signs, visible trauma to the skull of concern to the patient or carer)
- patient or carer incapable of transporting the patient safely to the hospital A&E Department without the use of ambulance services (providing any other risk factors indicating A&E referral are present)

Telephone advice services and web sites (e.g. NHS Direct, A&E helplines) should advise patients to refer themselves to a hospital A&E Department if the history related indicates the presence of any of the following risk factors (alternative terms to facilitate communication are in parenthesis):

- any loss of consciousness (‘knocked out’) as a result of the injury
- retrograde or post-traumatic amnesia (‘problems with memory’)
- persistent headache since the injury
- any vomiting episodes since the injury
- any seizure (‘convulsion’ or ‘fit’) since the injury
- any previous cranial neurosurgical interventions (‘brain surgery’)
- a high-energy head injury (e.g. pedestrian struck by motor vehicle, occupant ejected from motor vehicle, a fall from a height of greater than three feet or more than five stairs, diving accident, high-speed motor vehicle collision, rollover motor accident, accident involving motorized recreational vehicles, bicycle collision, or any other potentially high energy mechanism)
- history of bleeding or clotting disorder
- current anticoagulant therapy such as warfarin
- current drug or alcohol intoxication
- age \( \geq 65 \) years
- suspicion of intentional injury
- irritability or altered behaviour (‘easily distracted’ ‘not themselves’ ‘no concentration’ ‘no interest in things around them’) in infants and young children (i.e. less than 5 years)
- continuing concern by the helpline personnel about the diagnosis

The helpline should advise the patient to seek medical advice from community services (e.g. General Practice) if any of the following factors are present (in the absence of any the above factors):

- irritability and altered behaviour in children and adults
• adverse social factors (e.g. no-one able to supervise the patient at home)
• continuing concern by the patient or carer about the diagnosis

This is a grade D recommendation based on evidence level five.

3.4 Community health services and NHS minor injury clinics

Community health services (General Practice, paramedics, NHS walk in clinics, dental practitioners) and NHS minor injury clinics should refer head injured patients to a hospital A&E department if any of the following is present:

• GCS < 15 at any time since injury
• any loss of consciousness as a result of the injury
• any focal neurological deficit since the injury (examples include problems understanding, speaking, reading or writing; decreased sensation; loss of balance; general weakness; visual changes; abnormal reflexes; and problems walking)
• any suspicion of a skull fracture or penetrating head injury since the injury (e.g. clear fluid running from the ears or nose, black eye, penetrating injury signs, visible trauma to the skull of concern to the professional)
• retrograde or post-traumatic amnesia
• persistent headache since the injury
• any vomiting episodes since the injury
• any seizure since the injury
• any previous cranial neurosurgical interventions
• a high-energy head injury (e.g. pedestrian struck by motor vehicle, occupant ejected from motor vehicle, a fall from a height of greater than three feet or more than five stairs, diving accident, high-speed motor vehicle collision, rollover motor accident, accident involving motorized recreational vehicles, bicycle collision, or any other potentially high energy mechanism)
• history of bleeding or clotting disorder
• current anticoagulant therapy such as warfarin
• current drug or alcohol intoxication
• age $\geq$ 65 years
• suspicion of intentional injury
• continuing concern by the professional about the diagnosis

The professional should also consider referral to A&E if any of the following factors are present (in the absence of any of the above factors) depending on their own judgement of severity:

• irritability or altered behaviour in infants and young children (i.e. less than 5 years)
• visible trauma to the skull of concern not covered above but still of concern to the professional
• adverse social factors (e.g. no-one able to supervise the patient at home)
• continuing concern by the patient or carer about the diagnosis
3.5  **Transport from community health services and NHS minor injury clinics**

Patients referred from community health services and NHS minor injury clinics should be accompanied during transport to A&E. The referring professional should determine if an ambulance is required based on the patient’s clinical condition. If an ambulance is deemed not required, public transport and car are appropriate means of transport providing the patient is accompanied. The referring professional should inform the destination hospital (by phone) of the impending transfer and in non-emergencies a letter summarising signs and symptoms should be sent with the patient.

3.6  **Training in risk assessment**

It is recommended that General Practitioners, nurse practitioners, dentists and paramedics should all be capable of assessing the presence or absence of the risk factors listed in 3.4 above. There is some evidence that paramedics using written triage guidelines in a United States context may fall short of acceptable levels of triage accuracy. The GDG is under the impression that the triage skills of other community professionals may sometimes be below a desirable standard. Training should be available as required to ensure head injury triage accuracy in paramedics, GPs, nurse practitioners and dentists.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
Chapter 4. Immediate management at the scene and transport to hospital

4.1 Pre-hospital management

A full systematic review of all aspects of pre-hospital management for head injured patients was not possible within the timetable for this project. The GDG recommends that the following should be adhered to in immediate care.

- A head injured patient should initially be assessed and managed according to clear principles and standard practice as embodied in the Advanced Trauma Life Support (ATLS) system and for children the Advanced Paediatric Life Support (APLS) system.
- Paramedics should be fully trained in the use of the adult and paediatric versions of the GCS and its derived score.
- The first priority for those administering immediate care is to treat first the greatest threat to life and avoid further harm.
- Patients should be transported directly to a facility that has been identified as having the resources necessary to expeditiously assess and intervene to optimise patient outcome. It is expected that all acute hospitals accepting patients with a head injury should have these resources, and that these resources should be appropriate for the patient’s age.
- Head injured patients with a GCS < 15 should have full c-spine immobilisation attempted and then maintained if feasible until clearance by adequate imaging, unless other factors prevent this.
- Standby calls to the destination A&E Department should be made for all patients with a GCS ≤ 8, to ensure appropriately experienced professionals are available for their treatment and to prepare for imaging.
- An alerting call to the destination A&E Department should be made for all patients with a GCS < 15.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

4.2 Immediate management of patients with severe head injuries

There are specific questions regarding the early management of patients with severe head injuries (i.e. GCS < 9). Recent exhaustive systematic reviews have examined evidence on the management of severe traumatic brain injury. These reviews found evidence for only a small number of “standards” (i.e. recommendations generally based on class one evidence or strong class two evidence) and concluded that there was a paucity of well designed studies examining the efficacy of pre-hospital interventions in severe head injury.

Given these findings no changes to current practice are recommended in the pre-hospital management of severely head injured patients. This stance will be reviewed in forthcoming versions of these guidelines depending on advances in the literature.
4.3 Advanced life support training for ambulance crews

The value of advanced life support (ALS) training for ambulance crews over basic life support training (BLS) is controversial. ALS trained ambulance crews receive extra training in endotracheal intubation, intravenous cannulation, the administration of intravenous fluids and the use of selected drugs. A recent Cochrane systematic review concluded that insufficient evidence existed on the effectiveness of ALS training for ambulance crews.3

Given this finding no change to current practice in ALS training for ambulance crews is recommended in these guidelines. This stance will be reviewed in forthcoming versions of these guidelines depending on advances in the literature.

4.4 Priority dispatch of emergency ambulances

The use of an emergency medical dispatch (EMD) system is controversial. The EMD system requires a form of telephone triage carried out by ambulance dispatchers to determine the urgency of the emergency. A recent systematic review found little evidence on the effectiveness of EMD in terms of improved patient outcomes.4 However, a recent study on the acceptability of EMD in a UK context found increased satisfaction among callers to the 999 service. The amount of first aid advice and general information received by the service users increased while satisfaction with response times was maintained.3

Given these findings no change to current practice in EMD is recommended in these guidelines. This stance will be reviewed in forthcoming versions of these guidelines depending on advances in the literature.

4.5 Summary

In summary there is insufficient evidence to support treatment standards for almost all pre-hospital interventions and it is strongly recommended that research on the effectiveness of pre-hospital interventions becomes a high priority for UK research funding bodies. On the principle that absence of evidence of effectiveness is not evidence of absence of effectiveness, no changes to current practice in pre-hospital interventions are recommended in the current version of these guidelines.

This is a grade D recommendation based on evidence level five.
Chapter 5. Assessment in A&E

5.1 Introduction

The main risk to patients who have suffered a recent head injury is the development of a clinically important brain injury. These may be direct brain injuries (e.g. subdural haematoma) or extra cerebral injuries which secondarily compromise the brain (e.g. extradural haematoma). Some brain injuries require an early neurosurgical intervention (e.g. intracranial haematoma requiring evacuation) but the life threatening nature of the injury makes early detection essential. Other clinically important brain injuries do not provide an immediate threat to the patient but may produce late sequelae. Early identification of these latter injuries should assist in the patient’s rehabilitation.

The main focus of assessment for head injured patients in A&E should be the risk of clinically important brain injuries and injuries to the c-spine and the consequent need for imaging. Due attention must also be paid to any other patient injuries and to other concerns the clinician may have (e.g. intentional injury, possible non-head injury aetiology such as seizure). Early imaging, rather than admission and observation for neurological deterioration will reduce the time to detection for life-threatening complications and is associated with better outcomes.1,2

These recommendations are based on level five evidence and are considered to be grade D recommendations.

5.2 Primary investigation - head

The current primary investigation of choice for the detection of acute clinically important brain injuries is CT imaging of the head, carried out at an appropriate period post-injury (at least two hours post-injury unless the patient has risk factors that demand immediate imaging).

For logistic and resource reasons, MRI scanning is not currently indicated as the primary investigation for clinically important brain injury in head injured patients, although it is recognised that additional information of importance to the patient’s prognosis can sometimes be detected using MRI.3 MRI safety and availability may improve in the future to the point where it becomes a realistic primary investigation option for these patients.

SXRs have a role when there is a suspicion of intentional injury in infants and young children (aged < 5 years), in conjunction with other established investigations (e.g. CT, MRI, opthalmoscopic examination for retinal haemorrhage). SXRs also have a role in cases of penetrating head injury, or where CT scanning resources are unavailable. However, it is expected that instances of the latter case will be extremely rare and eventually non-existent.

These recommendations are based on level one, two and three evidence and are considered to be grade B recommendations.
5.3 Primary investigation – cervical spine

There is a 2-6% incidence of significant c-spine injury in patients who are symptomatic following trauma. These patients require clinical and radiographic clearance of the c-spine before removal of an immobilisation device. The major consequence of a missed bony or ligamentous injury is neurological injury.

5.3.1 Imaging options

There are four options for imaging of the c-spine. It is recognised that technological advances in imaging modalities may make the following discussion obsolete in the future.

- Plain films:
  - cross table lateral
  - film series (with swimmer’s view for C/T junction if required)
  - film series including ‘trauma obliques’
- Lateral flexion/extension series – immediate and/or delayed
- CT (localised or whole c-spine including cervico/dorsal junction)
- Magnetic Resonance Imaging

5.3.1.1 Plain films

When adequate visualisation of the entire c-spine is achieved a negative predictive value for a three-view series has been quoted as between 93-98%. Sensitivity however varies from 62.5-84% in these high risk populations. It is estimated that in a high risk population one in six c-spine injuries would be missed relying on an adequate three-view plain film series alone. If fractures that become clinically apparent are used as the gold standard then sensitivity is approximately 94% and overall specificity 96% in a low risk group.

There is evidence that five-view c-spine radiography does not improve predictive value compared to three view radiography with CT as the gold standard. The use of a lateral view alone will miss a significant proportion of injuries detected by a three view series.

Major trauma patients are more difficult to evaluate with plain films and specificity decreases to 79-89%, mainly due to inadequate or incomplete studies. The most common reason for this is poor visualisation of the cervico-dorsal junction.

5.3.1.2 Lateral flexion/extension views

In alert symptomatic patients, lateral flexion/extension views can be safely performed over the pain-free range. Studies have shown significant false positive and false negative rates. Ten per cent of ‘normals’ may have ‘abnormal’ flexion/extension views.
There is controversy over the safety of using of fluoroscopically guided passive flexion and extension to assess obtunded patients.

5.3.1.3 CT imaging of the cervical spine

CT imaging of the c-spine may be localised (e.g. craniocervical or cervico-dorsal to clarify a clinical or plain radiographic area of suspicion), or cover the whole c-spine. Modern multislice helical CT scanners enable the whole c-spine to be scanned at high resolution with ease. Multiplanar reformatted images can be generated rapidly on modern workstations.

Several studies report 100% sensitivity for detection of injuries in areas poorly visualised or suspicious on plain films. These studies are flawed however in that they have not used an alternative gold standard. If CT imaging of the head has been requested the cost of cervical CT is reduced and can be accomplished quickly and without patient transfer.

5.3.1.4 Magnetic Resonance Imaging (MRI) of the cervical spine

There is evidence that MRI detects a higher proportion of MRI of soft tissue abnormalities when performed within 48 hours of injury than plain film and CT but the clinical significance of these injuries is unclear. MRI is less effective than CT in the detection of bony injury. It has also been demonstrated that MRI can miss ligamentous injuries if delayed. Injuries of the mid-cervical spine, especially subluxation and lateral fractures are associated with vertebral artery injury which may be depicted by MRI.

5.3.2 Occipital condyle injuries

Occipital condylar fractures are uncommon injuries associated with high-energy blunt trauma to the head and/or upper c-spine. They are difficult to diagnose clinically but should be suspected in any patient showing signs of lower cranial nerve palsy after injury. Demonstration on plain films is extremely difficult and radiological diagnosis requires good quality CT.

5.3.3 Preferred investigations for the cervical spine

The current investigations of choice for the detection of injuries to the c-spine are three view plain radiographs of good technical quality. Where it is not possible to achieve the c-spine views desired with x-ray, CT imaging is indicated.

CT is indicated if the plain film series is technically inadequate, suspicious or definitely abnormal or if there is continued clinical suspicion of injury despite a normal study. As a minimum, CT should cover any areas of concern or uncertainty on plain film or clinical grounds. With modern multislice scanners the whole c-spine can be scanned at high resolution with ease and multiplanar reformatted images generated rapidly. This is particularly appropriate if the patient is having other body areas scanned for head injury/multi-region trauma.
MRI is indicated in the presence of neurological signs and symptoms referable to the c-spine and if there is suspicion of vascular injury (e.g. subluxation or displacement of the spinal column, fracture through foramen transversarium or lateral processes, posterior circulation syndromes). MRI may also add important information about soft tissue injuries associated with bony injuries demonstrated by plain films and/or CT. MRI has a role in the assessment of ligamentous and disc injuries suggested by plain films, CT or clinical findings.

The occipital condyle region should be routinely reviewed on “bone windows” in head injured patients. Reconstruction of standard head images onto a high resolution bony algorithm is readily achieved with modern CT scanners. In patients who have suffered high energy trauma or showing signs of lower cranial nerve palsy, additional high resolution imaging for coronal and sagittal reformatting should be performed while the patient is on the scanner table.

**These recommendations are based on level five evidence and are considered to be grade D recommendations.**

5.3.4 Infants and children

There is a lack of literature on decision rules for c-spine imaging in infants and children. It is recognised that physical examination of an immobilised, distressed child can be extremely difficult. Based on consensus the following recommendations were formulated by the GDG:

Children aged 10 years or more can be treated as adults for the purposes of c-spine imaging. Children under 10 years should receive anterior/posterior and lateral views without an anterior/posterior peg view. Abnormalities or uncertainties in those under 10 years should be clarified by CT imaging. Minor trauma associated with subsequent torticollis results in plain films that are almost uninterpretable and CT is very helpful in this situation

**This recommendation is based on level five evidence and is considered to be a grade D recommendation.**

5.4 Selection of patients for CT imaging of the head

A systematic review of clinical decision rules for selection of patients for CT imaging of the head was carried out according to the methods outlined in Chapter Two. Seven level one studies were identified. It was agreed that the review would focus on this evidence, but also give due cognisance to the findings of one level two study that reported on the first part of a project likely to produce highly important level one evidence.

The studies may be divided into contextual information and actual decision rules. Four studies provide high quality evidence on the following important contextual issues. First, SXR is of limited value in assisting the diagnosis of ICH as the sensitivity of a positive finding is only 38%. While it is true that a finding of skull
fracture on radiography significantly elevates the risk of ICH (specificity was 95%) one cannot rule out ICH on the basis of a negative radiograph.

Second, patients with a negative CT scan and no other body system injuries or persistent neurological finding means can be safely discharged. The negative predictive power quoted in this study was 99.7%.

Third, a 100% strategy of either CT imaging or high quality in-patient observation for minor/mild head injured patients will be 100% sensitive. The task is therefore to derive a more sophisticated clinical decision rule for patient selection that will improve specificity without impairing sensitivity.

We are then left with four papers which discuss decision rules for selecting patients for CT imaging which attempt to identify those at a high risk for traumatic brain injury (usually ICH). On examination of these papers it was felt that one paper had validated the rules in a population with a much lower prevalence of abnormal CT scans than an average UK population and this paper was not considered. A second paper described a rule that had only a 65% sensitivity for abnormal CT scan results and was also not considered further. The sensitivity of these rules have been questioned in another study.

This left two sets of rules, the Canadian CT-rules and the ‘New Orleans’ criteria. Two versions of the Canadian rules are available, a five point version designed to detect ‘need for neurological intervention’, and a seven point version designed to detect ‘clinically important brain injury’. The remit of these guidelines is on the latter outcome, and the seven point rule is therefore the focus of this review. However, it is recognised that the five point rule has some utility in determining the urgency with which CT imaging should be performed.

Both papers present high quality evidence, but strictly the New Orleans criteria represents level one evidence as it has used separate samples for the derivation and validation phases. The Canadian rules represent level two evidence as they have not yet been validated in a separate sample (this study is ongoing and will report in 2003). Both sets of authors caution against adoption of their rules, the Canadians because of the need for validation, and the New Orleans group because their rules were developed in one centre (the Canadian rules were developed in a multi-centre study).

It should be noted that the Canadian sample (N = 3,121) for a derivation sample, was much larger than the New Orleans sample (N = 520 in the derivation phase and N = 909 in the validation phase). This led to statistical power problems with certain key variables (e.g. coagulopathy) as not enough patients with these risk factors experienced a negative outcome.

It should also be noted that the Canadian paper considered a much broader range of possible predictive variables, and has outlined in great detail the steps taken to ensure the validity and reliability of the data. Both papers used recursive partitioning as the multivariate technique used to derive the rules.
Both papers excluded patients who had experienced no loss of consciousness. The New Orleans paper reports an overall abnormal CT rate of 6.5% and a surgical intervention rate of 0.4%, while the Canadian paper reports a rate of clinically important brain injury of 8% and a neurosurgical intervention rate of 1%. The Canadian paper included GCS = 13-15 patients (3.5% and 16.7% respectively) and assumed that all patients with GCS < 13 would receive immediate CT. The New Orleans paper focused on patients with GCS = 15 in the A&E Department (assuming that all patients with GCS < 15 would receive immediate CT) and therefore had a lower severity sample.

It should be noted that the Canadian sample has a similar profile of head injuries to a UK profile. The cohort used for the derivation of the Canadian Head CT rule contained 69% males, 11% ≥ 65 years, 26% road traffic accidents, 31% falls and 11% assaults. Alcohol contributed to at least 13% of head injuries.

Both papers report 100% sensitivity (95% CIs: 92-100) for need for neurosurgical intervention. The New Orleans criteria reports a 100% (95% CIs: 95-100) sensitivity for positive CT scans, whereas the Canadian 7-point rules are 98.4% (95% CIs: 96-99) sensitive for detecting clinically important brain injury. The New Orleans rules have a 25% (95% CIs: 22-28) specificity for detecting positive CT scans whereas the Canadian rules are reported to have a 49.6% (95% CIs: 48-51) specificity rate for detecting clinically important brain injury.

The New Orleans criteria would lead to a 78% CT ordering rate in patients with GCS = 15. The Canadian 7-point rules would lead to 54.3% ordering rate in patients with a GCS = 13-15.

It is important to note that the New Orleans paper reports 100% CT-scanning of the sample, whereas the Canadian paper had a scanning rate of only 67%, and the remaining 33% had a proxy outcome assessment via telephone interview. The final sample in the Canadian paper does not include some 10% of eligible patients who did not undergo CT and subsequently could not be contacted for follow-up.

The rules have the following similarities. Both suggest that patients with GCS < 15 on presentation at A&E should have immediate CT imaging. The only caveat to this is that the Canadian rules specify GCS < 15 two hours after injury. However, it should be born in mind that 93% of adults and 96% of children report to A&E with GCS = 15, implying that CT imaging for those with GCS < 15 will not greatly impact on resources. The area of controversy is generally accepted to relate to GCS = 15 patients.

Neither rule suggests a role for SXR or admission for observation without CT imaging. Both rules agree that vomiting should be included as an indication for imaging, although the Canadian rule specifies more than one episode.

Both rules agree that skull fracture signs (linear, basal, depressed, open, depressed, penetrating) should be an indication for CT imaging but these are defined and dealt with in different ways. In the New Orleans rules this is included as part of a category named ‘physical evidence of trauma above the clavicles’ which also includes
contusions, abrasions and lacerations. Presumably these would include facial surface wounds and not only wounds to the skull. The Canadian rules seem to have considered obvious penetrating skull injury or obvious depressed skull fracture as a priori indications for imaging and have also included any sign of basal skull fracture, and any ‘suspicion’ of open or depressed skull fracture as part of their rules.

Both rules include an age category. The New Orleans rules specify age > 60 years, and the Canadian rules specify age ≥ 65 years.

Both rules agree that post-traumatic seizure should be an indication for CT imaging, but the Canadian rules considered this an a priori variable, whereas it is explicitly included in the New Orleans rules.

It is also important to note that coagulopathy is not included in either set of rules but for very different reasons. The Canadian paper excluded these patients deliberately, presumably because they were considered a priori candidates for CT imaging. The New Orleans rules included these patients but did not have enough power to detect a significant predictive power. The New Orleans paper explicitly states that this variable was not considered by their study and imply that it should be considered an important predictive variable.

A further exclusion from both samples is focal neurological deficit (this is not completely clear from the New Orleans paper) again, presumably because CT imaging of the head for these patients was considered non-controversial.

The rules differ in their treatment of amnesia. The Canadian rules include pre-traumatic amnesia of greater than 30 minutes, whereas the New Orleans rules include ‘short-term memory deficits’ which is anterograde (i.e. for events after the injury).

The Canadian rules contain a variable called ‘dangerous mechanism’ (of injury), which is defined as a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than three feet or five stairs. The New Orleans rules did not consider this variable.

The New Orleans rules contain a headache variable, which was dropped from the Canadian rules.

The New Orleans rules contain a variable for drug or alcohol intoxication whereas this is not included in the Canadian rules. The Canadian authors seem to imply that having a variable ‘GCS < 15 after 2 hours’ will allow the less severe intoxications to resolve and eliminate a corresponding number of unnecessary scans. The Canadian authors measured ethanol levels in a sub-sample and found that it had no predictive power for the outcomes studied.

Two evidence based decision rules for selection of patients for CT imaging have been described. There is no clear means of choosing one over the other, and the decision on which rule to choose was therefore based on consensus. Based on the
GDG consensus, it was decided that the seven point Canadian CT head rules should be used to identify patients who will need CT imaging of the head.

In order to provide guidance that covers all possibilities, the seven point Canadian CT rule has been slightly adapted as follows.

- It is assumed that patients with post traumatic seizure, focal neurological deficit or coagulopathy should be included in the rule.
- It is assumed that patients with ‘risk factors’ (i.e. age $\geq 65$ years, coagulopathy, dangerous mechanism of injury) should at least have had an instance of loss of consciousness or post-traumatic amnesia (i.e. the main signs and symptoms used to screen patients for inclusion in the Canadian CT-head rule study) before receiving CT. This is to prevent the possibility of patients with no signs or symptoms receiving a CT.

Patients with any one of the following signs or symptoms should have CT scanning of the head immediately requested:

- GCS $< 13$ at any point since the injury
- GCS $= 13$ or $14$ at two hours after the injury
- suspected open or depressed skull fracture
- any sign of basal skull fracture (haemotympanum, ‘panda’ eyes, cerebrospinal fluid otorrhoea, Battle’s sign)
- post traumatic seizure
- focal neurological deficit
- more than one episode of vomiting
- amnesia for greater than 30 minutes of events before impact

CT should also be immediately requested in the following patients, provided they have experienced some loss of consciousness or post-traumatic amnesia since the injury:

- age $\geq 65$ years
- coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin)
- dangerous mechanism of injury (a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than three feet or five stairs)

This recommendation is based on level two evidence and is considered to be a grade B recommendation.

The GDG considers this recommendation to be interim and dependant on future research likely to appear in the literature within the next five years. These include the validation phase of the Canadian CT head rules, and a new clinical decision instrument based upon the NEXUS II study. The latter study intends to recruit approximately 15,000 patients to the overall project (derivation and validation).
5.5 Selection of patients for imaging of the cervical spine

A systematic review of clinical decision rules for selection of patients for imaging of the c-spine was carried out according to the methods outlined in Chapter Two. Two level one studies were identified. These were the NEXUS study group from America and the Canadian c-spine rule. The Canadian c-spine rule is included as a level one study as the validation study has recently been presented at scientific meetings although at the time of writing the validation study has not yet appeared in a peer reviewed journal.

The remaining papers that were reviewed all contained non-level one evidence for a variety of rules and were derived in small cohorts. In addition some papers considered a variety of different aspects of c-spine imaging. These included studies in obtunded patients, studies on the utility of flexion-extension views, studies in children and studies on the utility of CT scanning or MRI scanning. These studies are included in the evidence table but contribute little to the decision as to which rule to use to exclude low risk patients from cervical imaging.

The Canadian c-spine rule involves the following questions:

- Is there any high risk factor present that mandates radiography: age $\geq 65$ years, dangerous mechanism, or paraesthesia in the extremities?
- Is there a low risk factor present that allows the safe assessment of range of motion (i.e. simple rear-end motor vehicle collision, sitting position in ED, ambulatory at any time since injury, delayed onset of neck pain, absence of midline c-spine tenderness?)
- Is the patient able to actively rotate their neck 45 degrees to the left and right?

For the NEXUS rule, absence of five criteria are used to classify the patient as low risk:

- No midline cervical tenderness
- No focal neurological deficit
- Normal alertness
- No intoxication
- No painful distracting injury

Both papers present high quality evidence, the NEXUS rule is level one evidence although they validated their rule by asking each doctor whether the patient was high or low risk using the rule rather than compelling the attending physician to follow the rule. The Canadian c-spine rule represents level two evidence as the derivation sample is presented here. The validation study has however now been completed and successfully validates the rule. The validation study has been presented at scientific meetings but at the time of writing has not yet appeared in a peer-reviewed journal. In the likely event that this occurs it will be considered level one evidence.

The NEXUS study collected prospective data on 34,069 patients in twenty-one hospitals in the USA who underwent cervical imaging following blunt trauma.
Included were patients of all levels of alertness, and children. The Canadian c-spine rule studied 8,924 patients in ten large Canadian community and university hospitals who underwent cervical imaging following blunt trauma. Only adults who were GCS = 15 were included.

The Canadian c-spine rule excluded patients who were not fully alert (i.e. GCS = 15). The NEXUS rule included all levels of alertness. The NEXUS paper reports an overall cervical fracture rate of 2.4% and a clinically significant fracture rate of 1.7%, while the Canadian paper reports an overall fracture rate of 2.0% with a clinically significant c-spine fracture rate of 1.7%. The NEXUS rule had no age exclusion whereas the Canadian rules were derived and validated only on patients over 16 years old.

The Canadian c-spine rule gives a sensitivity of 100% (95% CIs: 98-100) and NEXUS gives a sensitivity of 99.6% (95% CIs: 98.6-100). The NEXUS rule is not 100% sensitive but of the two clinically significant missed fractures one had an extension-teardrop fracture and self discharged. He was well at six months. One had a fracture of the right lamina of the sixth cervical vertebra requiring open fixation, but may have been incorrectly classified as low risk by the institution as he had loss of consciousness and neurology. Of interest, Stiell et al tested the NEXUS rule on the Canadian c-spine cohort and found that the sensitivity of the NEXUS rule was only 93%. They also criticise the NEXUS rule for the poor reproducibility of ‘presence of intoxication’ and ‘distracting painful injuries’.

The main difference between the two rules lies in the specificity. The NEXUS rule has a specificity of 12.9% (95% CIs: 12.8-13.0) whereas the specificity of the Canadian c-spine rule is 42.5% (95% CIs: 40-44) for clinically significant injuries. In addition the Canadian c-spine rule detected 27 out of 28 clinically insignificant spine fractures.

Because of the very large difference in specificity the ordering rate produced by the two rules is also markedly different. The NEXUS rule requires an 87% three view plain radiography rate, whereas the Canadian c-spine rule requires a 58.2% rate. It is important to note that NEXUS only found 498 of the 818 c-spine abnormalities on plain radiography, as a very high number of plain radiographs were of inadequate quality. Another issue of concern is that 23 of the cervical fractures that were categorised as high risk by the NEXUS rule had plain radiographs that missed the fracture even though they were of good quality. These fractures were only picked up as further imaging was performed. The Canadian c-spine rule paper did not comment on how many of their plain radiographs were of inadequate quality, and therefore how many people had their fracture picked up by additional imaging.

In the Canadian study, 68% of all patients underwent plain radiography. All patients were telephoned at 14 days to assess for any missed injuries, as there was no other universal gold standard imaging applied, but 577 patients originally entered into the study could not be traced by telephone and did not have a c-spine radiograph and so were later excluded. This is clearly of methodological concern. The NEXUS study performed three view imaging in 87% of all patients. They had a different follow up
Two evidence based decision rules for selection of patients for imaging of the c-spine have been described. There is no clear means of choosing one over the other, and the choice of rule was therefore based on consensus. Based on the GDG consensus, it was decided that the Canadian c-spine rules should be used to identify patients who will require imaging of the c-spine.

In order to provide guidance that covers all possibilities, the Canadian c-spine rule has been slightly adapted as follows.

- It is assumed that all patients with GCS < 15 should have c-spine imaging.
- It is assumed that patients with focal neurological deficit should be included in the rule.
It is assumed that patients who are aged \( \geq 65 \) years, or who have had a dangerous mechanism of injury should at least have had an instance of neck pain or tenderness before receiving c-spine imaging.

Patients with any one of the following signs or symptoms should have three view radiograph imaging of the c-spine immediately requested:

- GCS < 15
- paraesthesia in the extremities
- focal neurological deficit
- not possible to test for range of motion in the neck (safe assessment of range of motion can be performed with the following: simple rear-end motor vehicle collision, sitting position in A&E, ambulatory at any time since injury, delayed onset of neck pain, absence of midline c-spine tenderness)
- patient not able to actively rotate neck to 45 degrees to the left and right (if assessment is possible)

C-spine imaging should also be immediately requested in the following patients provided they have experienced some neck pain or tenderness:

- aged \( \geq 65 \) years
- dangerous mechanism of injury (fall from \( \geq 1 \) meter or 5 stairs; axial load to head e.g. diving; high-speed motor vehicle collision greater than 65 miles per hour; rollover motor accident; ejection from a motor vehicle; accident involving motorized recreational vehicles; bicycle collision)

This recommendation is based on level two evidence and is considered to be a grade B recommendation.

The GDG considers this recommendation to be interim and dependant on future research likely to appear in the literature within the next year, specifically the peer reviewed publication of the validation phase of the Canadian c-spine rules.

5.6 Using adult rules with infants and children

The literature on head injury in infants and children has not to date produced a highly sensitive and specific clinical decision rule based on level one evidence that can be used to select patients for imaging. There is evidence that the prevalence of intracranial complications in children and infants is much lower than in adults but to date no clearly defined rules with acceptable sensitivity and specificity have been produced. The literature on SXR in children and infants indicates that, as with adults, the specificity of SXR is too low to be the primary investigation (i.e. the absence of skull fracture does not predict absence of intra-cranial complications). In studies which have included both children and adults, there is evidence that adult rules can be safely applied to children, but these studies have suffered from statistical power problems. The evidence regarding the safety of adult rules with infants is inconclusive.
As the best evidence on selecting head injured patients for imaging exists for adults, and children and infants have a lower risk of brain and c-spine injury than adults, validated adult rules on imaging of the head and c-spine may be safely used in children and infants.

**These recommendations are based on level five evidence and are considered to be grade D recommendations.**

Validated clinical decision rules on the selection of infants and children for imaging are urgently required. It is recommended that research on this topic be prioritised by funding bodies in this area.

5.7 **Piloting the new rules**

The process of implementing these guidelines is beyond the GDG but it is strongly recommended that the clinical decision rules advocated in this Chapter be piloted at a small number of representative hospitals before being broadly adopted. The GDG is aware that both the head and c-spine imaging rules advocated here were derived from Canadian samples, where the proportion of patients suffering assaults is much lower and the proportion suffering road traffic accidents much higher. It is unclear how this could impact on the sensitivity and specificity of the rules in a UK context.

5.8 **Intentional injury in infants and young children**

These guidelines are not intended to cover the acute management of intentionally inflicted injury, but it is important that health professionals are aware that the head injury examination is an important opportunity to screen for this problem. There is evidence that a distinct pattern of brain injuries are associated with intentional injury in infants and young children. This results from the different mechanisms of injury in accidental versus intentional head injury. Intentional injuries are more likely to involve inertial forces (e.g. shaking) whereas intentional injuries are more likely to involve blunt trauma.37

Due to the distinct pattern of injuries involved, SXR along with other well-established investigations (e.g. CT, MRI, opthalmoscopic examination for retinal haemorrhage) have a role in detecting intentional head injuries in infants and young children (aged < five years).

**This recommendation is based on level five evidence and is considered to be a grade D recommendation.**

Work on the derivation of clinical decision rules to predict intentional injury based on imaging patterns has recently been begun.38 However, the decision rules in this area will require substantial validation before they can inform clinical practice. Future versions of this guideline should determine the status of research in this area.

5.9 **Good practice in A&E assessment**

The following should be followed during A&E assessment.
The priority for all A&E patients is the stabilisation of airways, breathing and circulation (ABC) before attention to other injuries.

Patients presenting to A&E with impaired consciousness (GCS < 15) should be assessed immediately by a trained member of staff (e.g. triage nurse).

All head injury patients presenting to A&E should have been assessed by triage by a trained member of staff within a maximum of 15 minutes of arrival at hospital. Part of this assessment should establish whether they are high risk or low risk for clinically important brain injury and/or c-spine injury, using the Canadian rules outlined above.

Patients found to be high risk on triage for clinically important brain injury and/or c-spine injury should be assessed within 10 minutes of triage by an A&E clinician. Part of this assessment should fully establish the need for CT imaging of the head and/or imaging of the c-spine. The Canadian rules outlined above should again form the basis for the final decision on imaging.

Head injured patients who are discovered to be low risk on initial triage for clinically important brain injury and/or c-spine injury should be assessed within a further hour by an A&E clinician. Part of this assessment should fully address the need for CT imaging of the head and/or imaging of the c-spine. The Canadian rules outlined above should again form the basis for the final decision on imaging.

In principle head injured patients should not receive systemic analgesia until fully assessed so that an accurate measure of consciousness and other neurologic signs can be made. Local or regional anaesthetic should be delivered for fractured limbs or other painful injuries.

Throughout the hospital episode, all care professionals should use a standard head injury proforma in their documentation when assessing and observing head injured patients. A separate proforma for those under 16 years should be used. Areas to allow extra documentation should be included (e.g. in cases of intentional injury). Excellent proformas have been produced in previous guideline produced by the Scottish Intercollegiate Guidelines Network (see Appendices).³⁹

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
Chapter 6. Imaging practice and involving the neurosurgical department.

6.1 Introduction

A full systematic review of all issues relating to the effective and safe performance of radiological imaging in head injured patients was beyond the timetable of this project. It is assumed that general principles of good practice in imaging will be adhered to, as outlined in publications by the Royal College of Radiologists. On the basis of consensus, the GDG has made the following recommendations.

- All CT scans of the head should be reviewed by a clinician who has been deemed competent to review such images.
- All plain radiographs of the c-spine should be reviewed by a clinician who has been deemed competent to review such images.
- Where necessary, transport or transmission of images should be used to ensure that a competent clinician review the images.
- All imaging performed on head injured patients should have a full or interim written report for the patients’ notes within an hour of the procedure having been performed.
- Imaging of any kind should not delay neurosurgical or anaesthetic referral in the more severely head injured patient.
- All A&E Departments responsible for the management of head injured patients should have:
  - sufficient CT scanning and other imaging (e.g. SXR, MRI) equipment capacity;
  - sufficient imaging transfer facilities;
  - and sufficient radiography and radiology staff;
  - on a 24 hour basis to deal with the volume of head injured patients they are likely to receive.

These recommendations are based on level five evidence and are considered to be a grade D recommendation.

6.2 Computed tomography of the head urgency

Given the demands on CT scanners and radiologists trained in their use it is important to distinguish between those patients for whom CT imaging is ‘immediate’, ‘urgent’ and ‘within a reasonable period’.

CT should be performed immediately in patients with GCS < 9 at any point since the injury.

Given that the current guidelines propose selection for imaging based upon the Canadian CT-head rules it is possible to distinguish between those patients at high risk for need for neurosurgical intervention and those at high risk for clinically important brain injuries. The former set of patients will need CT imaging urgently
(i.e. within one hour) whereas the latter patients can wait for a reasonable period before imaging.

CT imaging of the head should be performed within one hour of the request having been received by the radiology department (but no earlier than two hours post-injury) in those patients with any of the following symptoms or signs:

- GCS = 13 or 14 at two hours after the injury
- suspected open or depressed skull fracture
- any sign of basal skull fracture (haemotympanum, ‘panda’ eyes, cerebrospinal fluid otorrhoea, Battle’s sign)
- more than one episode of vomiting
- age $\geq$ 65 years, providing that some loss of consciousness or post-traumatic amnesia has been experienced
- post traumatic seizure
- coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or post-traumatic amnesia has been experienced
- focal neurological deficit

Patients who have any of the following symptoms and none of the above symptoms should have their CT imaging performed as soon as possible (provided two hours have passed since the injury) but within 8 hours of the request having been received by the radiology department:

- amnesia for greater than 30 minutes of events before impact
- dangerous mechanism of injury (a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than three feet or five stairs) providing that some loss of consciousness or post-traumatic amnesia has been experienced

**These recommendations are based on level two evidence and are considered to be grade B recommendations.**

### 6.3 Cervical spine imaging urgency

The demands on x-ray facilities are not as pressing as those on CT facilities and there is no consequent need to discriminate between different categories of patient requiring c-spine imaging. C-spine imaging if indicated should be carried out urgently as these patients will often need CT of the head once the c-spine has been cleared.

Imaging of the c-spine should be performed within one hour of an urgent request having been received by the radiology department. Where a request for urgent head CT (i.e. within one hour) has also been received, the c-spine imaging should be carried out immediately.
This recommendation is based on level five evidence and is considered to be a grade D recommendation.

6.4 Involving neurosurgical care

The care of all patients with new, surgically significant abnormalities on imaging should be discussed with a neurosurgeon. Examples of lesions not surgically significant are:

- solitary contusion < 5mm in diameter (MRI scan should be considered however)
- thin localised subarachnoid blood (the possibility that the blood has originated from spontaneous rupture of a vascular malformation such as an aneurysm should always be considered)
- smear subdural haematoma < 4mm thick (the presence of a smear subdural haematoma may be surgically significant in the presence of brain swelling as evidenced by brain shift on the CT scan)
- isolated pneumocephaly
- closed depressed skull fracture not through the inner table.

There should be lower thresholds for involving neurosurgical care in infants and children, as smaller lesions may be more significant here.

This definition is based on a formal survey of 129 academic neurosurgeons, neuroradiologists and emergency physicians in Canada.²

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

It would be desirable if the above exclusion criteria could be based on the opinion of UK neurosurgeons, but no such consensus currently exists. It is recommended that research on this topic be prioritised by the Department of Health in conjunction with the Society of British Neurological Surgeons.

6.4.1 Other reasons for discussing a patient’s care with a neurosurgeon

Regardless of imaging, other reasons for discussing a patient’s care plan with a neurosurgeon include:

- persisting coma (GCS < 8) after initial resuscitation;
- unexplained confusion which persists for more than 4 hours;
- deterioration in GCS score after admission (greater attention should be paid to motor response deterioration);
- progressive focal neurological signs;
- a seizure without full recovery;
- definite or suspected penetrating injury;
- a CSF leak.
These criteria are based on both GDG consensus and recommendations from previous guidelines.³

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

6.4.2 Criteria for neurosurgical interventions

It was not possible to examine criteria for neurosurgical interventions in the time allowed for this project. This project has assumed best practice will be followed once neurosurgeons have become involved with a particular patient.

6.5 Transfer from secondary to tertiary care settings

The risk of a further injury to patients during transfer to tertiary care is well established.⁴ Transfer of the patient between a general hospital and a neurosurgical unit should follow the principles set out by the Neuro-anaesthesia Society of Great Britain and Ireland and the Association of Anaesthetists of Great Britain and Ireland.⁵ The recommendations are listed below, with a slight modification to section four based on discussion amongst the GDG.

1. There should be a designated consultant in the referring hospital with overall responsibility for the transfer of patients with head injuries to the neurosurgical unit (i.e. a department of neurosurgery with appropriate supporting services including neuroanaesthesia, neuro-intensive care and neuroradiology) and one at the neurosurgical unit with overall responsibility for receiving the transfers.

2. Local guidelines on the transfer of patients with head injuries should be drawn up between the referring hospital trusts and the neurosurgical unit and should be consistent with established national guidelines. Details of the transfer of the responsibility for patient care should also be agreed.

3. Thorough resuscitation and stabilisation of the patient must be completed before transfer to avoid complications during the journey. A patient persistently hypotensive, despite resuscitation, must not be transported until all possible causes of the hypotension have been identified and the patient stabilised.

4. Only in exceptional circumstances should a patient with an altered conscious level requiring transfer for neurosurgical care not be intubated. All patients with a GCS ≤ 8 should be intubated and ventilated as should any patients with the indications detailed in point 8 below.

5. Patients with head injuries should be accompanied by a doctor with at least two years experience in an appropriate specialty (usually anaesthesia). They should be familiar with the pathophysiology of head injury, the drugs and equipment they will use, working in the confines of an ambulance (or helicopter if appropriate) and have received supervised training in the transfer
of patients with head injuries. They must have an adequately trained assistant. They must be provided with appropriate clothing for the transfer, medical indemnity and personal insurance.

6. The transfer team must be provided with a means of communication with their base hospital and the neurosurgical unit during the transfer – a portable phone may be suitable.

7. Education, training and audit are crucial to improving standards of transfer; appropriate time and funding should be provided.

8. The following indications for intubation and ventilation after head injury should be used:

   a. Immediately:
      i. Coma – not obeying commands, not speaking, not eye opening (i.e. GCS≤8)
      ii. Loss of protective laryngeal reflexes
      iii. Ventilatory insufficiency as judged by blood gases: hypoxaemia (PaO₂ < 9 kPa on air or < 13 kPa on oxygen) or hypercarbia (PaCO₂ > 6 kPa)
      iv. Spontaneous hyperventilation causing PaCO₂ < 3.5 kPa
      v. Respiratory arrhythmia

   b. Before the start of the journey:
      i. Significantly deteriorating conscious level, even if not coma
      ii. Bilateral fractured mandible
      iii. Copious bleeding into mouth (e.g. from skull base fracture)
      iv. Seizures

An intubated patient must be ventilated with muscle relaxation and appropriate sedation and analgesia. Aim for a PaO₂ > 13kPa, PaCO₂ 4.0 – 4.5 kPa.

Carers and relatives should have as much access to the patient as is practical during transfer and be fully informed on the reasons for transfer and the transfer process.

**These recommendations are based on level five evidence and are considered to be grade D recommendations.**

These principles are largely based on consensus, and their use should be audited in future research.

6.5.1 Transfer of children

Transfer of a child or infant to a specialist neurosurgical unit should be undertaken by staff experienced in the transfer of critically ill children. Families should have as much access to their child as is practical during transfer and be fully informed on the reasons for transfer and the transfer process.
This recommendation is based on level five evidence and is considered to be a grade D recommendation.
Chapter 7. Admission, observation, transfer to neurosurgical care

7.1 Introduction

These guidelines place the emphasis on the early diagnosis of clinically important brain and c-spine injuries, using a sensitive and specific clinical decision rule with early imaging. Admission to hospital is intrinsically linked to imaging results, on the basis that patients who do not require imaging are safe for discharge to the community (given that no other reasons for admission exist) and those who do require imaging can be discharged following negative imaging (again, given that no other reasons for admission exist). However, observation of patients will still form an important part of the acute management phase. Observation should occur throughout the patient’s hospital episode, whether in A&E or after admission following abnormal imaging results. As noted above, all care professionals should use a standard head injury proforma in their documentation when assessing and observing head injured patients. Separate adult, and child/infant specific proformas should be used. Again, the adult and paediatric GCS and derived scores should form the basis of observation, supplemented by other important observations.

An important result of these guidelines will be that the typical patient admitted for in hospital observation after head injury will have a more severe profile. It is presumed that the guidelines will lead to a substantially lower number of patients requiring admission, but these patients will have either confirmed abnormal imaging, have failed to return to normal consciousness or have other continuing signs and symptoms of concern to the clinician. The emphasis will shift therefore from vigilance for possible deterioration, to active care of patients where an ongoing head injury complication has been confirmed.

7.2 Admission

The following patients meet the criteria for admission to hospital following a head injury:

- patients with new, clinically significant abnormalities on imaging;
- patients who have not returned to GCS = 15 after imaging, regardless of the imaging results;
- when a patient fulfils the criteria for CT scanning but this cannot be done within the appropriate period;
- continuing worrying signs (e.g. persistent vomiting, severe headaches) of concern to the clinician;
- other sources of concern to the clinician (e.g. drug or alcohol intoxication, other injuries, shock, suspected intentional injury, meningism, CSF leak).

Some patients may require an extended period in a recovery setting due to the use of sedation or general anaesthetic during CT imaging. These patients should not normally require admission.
Patients with multiple injuries should be admitted under the care of the team that is trained to deal with their most severe and urgent problem.

These recommendations are based on level five evidence and are considered to be grade D recommendations.

7.3 Good practice in observation of head injured patients

There is some evidence that A&E observation wards are more efficient than general acute wards at dealing with short stay observation patients, with more senior supervision, fewer tests and shorter stays. There have also been concerns about the experience and skills of staff on general and orthopaedic acute wards in head injury care. This lead to a recommendation by the Royal College of Surgeons of England in 1999 that adult patients needing a period of observation should be admitted to a dedicated observation ward within or adjacent to an A&E Department.

It is recommended that in-hospital observation including all A&E observation should only be conducted by professionals competent in the assessment of head injury. In general, patients with a head injury should be admitted under the care of a consultant who has been trained in the management of this condition during his/her higher specialist training.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

The service configuration and training arrangements required to ensure this occurs are beyond the scope of these guidelines but it is hoped that this issue will be addressed by future NHS policy guidance.

7.3.1 Minimum documented observations

For patients admitted for head injury observation the minimum acceptable documented neurological observations are: GCS; pupil size and reactivity; limb movements; respiratory rate; heart rate; blood pressure; temperature; blood oxygen saturation.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

7.3.2 Frequency of observations

As the risk of an intracranial complication is highest in the first six hours after a head injury, observations should have greatest frequency in this period. Observations should be performed and recorded on a half-hourly basis until GCS = 15 has been achieved. The minimum frequency of observations for patients with GCS = 15 should be as follows, starting after the initial assessment in A&E:

- half-hourly for two hours
- then one hourly for four hours
• then two hourly thereafter

Should the GCS = 15 patient deteriorate at any time after the initial two-hour period, observations should revert to half-hourly and follow the original frequency schedule.

These recommendations are based on level five evidence and are considered to be a grade D recommendation.

7.4 Patient changes requiring review while under observation

Any of the following examples of neurological deterioration should prompt urgent reappraisal by the supervising doctor:

• development of agitation or abnormal behaviour
• a sustained (i.e. for at least 30 minutes) drop of one point in GCS level (greater weight should be given to a drop of one point in the motor score of the GCS)
• any drop of greater than two points in GCS level regardless of duration or GCS sub-scale
• development of severe or increasing headache or persisting vomiting
• new or evolving neurological symptoms or signs such as pupil inequality or asymmetry of limb or facial movement.

To reduce inter-observer variability and unnecessary referrals, a second member of staff competent to perform observation should confirm deterioration before involving the supervising doctor. This confirmation should be carried out immediately. Where a confirmation cannot be performed immediately (e.g. no staff member available to perform the second observation) the supervising doctor should be contacted without the confirmation being performed.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

7.5 Imaging following confirmed patient deterioration during observation

An immediate CT scan should be considered in patients confirmed as having any of the changes noted in 7.4 above.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

7.6 Further imaging if GCS = 15 not achieved at 24 hours

In the case of a patient who has had a normal CT-scan but who has not achieved GCS = 15 after 24 hours observation, a further CT scan or MRI scanning should be considered.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
7.7 Observation of children and infants

Observation of infants and children is a difficult exercise and therefore should only be performed by units with staff experienced in the observation of young children with a head injury. Infants and children may be observed in normal paediatric observation settings, as long as staff have the appropriate experience.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

7.8 Training in observation

It is recommended that medical, nursing and other staff caring for head injured patients admitted for observation should all be capable of performing the observations listed in 7.3.1 and 7.4 above. The acquisition and maintenance of observation and recording skills requires dedicated training and this should be available to all relevant staff. Specific training is required for the observation of infants and young children.

This is a grade D recommendation based on evidence level five.

7.9 Support for families and carers

Early support can help the patient’s family or carer(s) prepare for the effects of head injury. This support can reduce the psychological sequelae experienced by the family or carer and result in better long-term outcomes for both the patient and their family.

For a patient’s family; thrust suddenly into a hospital acute care setting with the range of faces and responsibilities, the shock can be overwhelming and cause additional tension or stress. Therefore a photographic board in the hospital departments caring for head injured patients with the names and titles of personnel would be helpful. There should also be a protocol for all staff to introduce themselves to family members or carers and briefly explain what they are doing. Again this is helpful in reducing stress on the part of the family.

Information sheets detailing the nature of head injury and any investigations likely to be used should be available in the A&E Department. The Great Ormond Street hospital fact sheet on head injury in children is an excellent example (available at http://www.ich.ucl.ac.uk/factsheets/misc/head_injury).

The presence of familiar friends and relatives at the early stage following admission can be very helpful. The patient recovering consciousness can easily be confused by strange faces and the strange environment in which they find themselves. Relatives or carers are often willing to assist with simple tasks which, as well as helping nursing staff, helps families to be part of the recovery process rather than
just an observer. Although there is little the relative can do clinically, talking and making physical contact, such as holding hands, can be helpful and aid recovery.

Such contact should be encouraged although it is important for relatives and friends not to feel that they have to spend many hours at the bedside. It is important that they also have a break and sleep from time-to-time. This may be an opportune moment to mention patient support organisations and introduce their literature.

It can be a traumatic experience for a child visiting a sibling or parent with a head injury. Staff should consider how best to share information with children and introduce them to the possibility of long-term complex changes in their parent or sibling. Again literature produced by patient support groups may be helpful.

There should be a board/area displaying leaflets or contact details for patient support organisations either locally or nationally such as Headway (Headway Helpline - 0808 800 2244) Children Brain Injury Trust (Helpline - 01865 552 487) Brain and Spine Foundation (BSF Helpline - 0808 808 1000), to enable family members to gather further information.

Voluntary support groups can speak from experience about the real life impact post head injury and can offer support following discharge from hospital. This is particularly important where statutory services are lacking.

**These recommendations are based on level five evidence and are considered to be grade D recommendations.**
Chapter 8. Discharge and follow-up

8.1 Introduction

Given that these guidelines place a lower emphasis on in-hospital observation, there is a need to ensure that patient discharge is safe and carefully planned. The role of carers at home in the early post-discharge observation of patients is important and should be guided by clear and detailed information. There must be clearly defined pathways back to hospital care for patients who show signs of late complications. There is also a clear need for systematic follow-up of all grades of patient, given the high likelihood of long-term disabilities.

8.2 Discharge of low risk GCS = 15 patients

If CT is not indicated on the basis of history and examination the clinician may conclude that the risk of head injury is low enough to warrant transfer to the community, as long as no other factors that would warrant a hospital admission are present (e.g. drug or alcohol intoxication, other injuries, shock, suspected intentional injury, meningism, CSF leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (e.g. competent supervision at home).

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

8.3 Discharge of patients with normal imaging of the head

After normal imaging of the head, the clinician may conclude that the risk of complications requiring hospital care is low enough to warrant transfer to the community, as long as the patient has returned to GCS = 15, and no other factors that would warrant a hospital admission are present (e.g. drug or alcohol intoxication, other injuries, shock, suspected intentional injury, meningism, CSF leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (e.g. competent supervision at home).

This recommendations is based on level five evidence and is considered to be a grade D recommendation.

8.4 Discharge of patients with normal imaging of the cervical spine

After normal imaging of the c-spine the clinician may conclude that the risk of injury to the c-spine is low enough to warrant transfer to the community, as long as the patient has returned to GCS = 15 and their clinical examination is normal, and no other factors that would warrant a hospital admission are present (e.g. drug or alcohol intoxication, other injuries, shock, suspected intentional injury, meningism, CSF leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (e.g. competent supervision at home).
This recommendation is based on level five evidence and is considered to be a grade D recommendation.

8.5 Discharge of patients admitted for observation

Patients admitted after a head injury may be transferred to the community after resolution of all significant symptoms and signs providing they have suitable supervision arrangements at home.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

8.6 Discharge of patients at risk of intentional injury

No infants or children presenting with head injuries that require imaging of the head or c-spine should be transferred to the community until assessed by a clinician experienced in the detection of intentional injury.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

It is expected that all personnel involved in the triage and assessment of head injured infants and children should have some training in the detection of intentional injury.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

Guidance on the process of transferring patients of all ages who may have suffered intentional injury, including liaison with appropriate community care and legal organisations are contained in a recent Department of Health manual.¹

8.7 Discharge and GCS status

No patients presenting with head injury should be transferred to the community until they have achieved GCS = 15, or normal consciousness in infants and young children as assessed by the paediatric version of the GCS.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

8.8 Discharge advice

All patients with any degree of head injury who, by all the criteria listed above, are to be appropriately transferred to the community from A&E or the observation ward, should receive verbal advice and a written head injury advice card. The details of the card should be discussed with the patients and their carers. If necessary, other formats (e.g. tapes) should be used to communicate this information. Communication in languages other than English should also be facilitated.
These recommendations are based on level five evidence and is considered to be a grade D recommendation.

The risk factors outlined in the card should be the same as those used in the initial community setting to advise patients on A&E attendance (see Chapter Three). Patients and carers should also be alerted to the possibility that some patients may make a quick recovery, but go on to suffer delayed complications. Instructions should be included on contacting community services in the event of delayed complications.

This is a grade D recommendation based on evidence level five.

Suggested written advice cards for patients and carers are provided in Appendix Two, Three and Four.

8.9 Discharge of patients with no carer at home

All patients with any degree of head injury should only be transferred to their home if it is certain that there is somebody suitable at home to supervise the patient.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

8.10 Outpatient appointments

It is well known that some patients labelled as having had a minor head injury may experience long-term disability following discharge from hospital. Symptoms such as headache, dizziness, memory deficits, communication problems, inability to work and problems with self-care have been described. These patients are categorised by the International Classification of Diseases (ICD-10) as having post-concussional syndrome (PCS).

Five papers were classed as level two evidence due to the quality of the study design. However from these papers, only one paper explicitly constructed a decision rule that could be used in the acute setting to identify patients at risk of PCS. This rule identifies a high-risk group that has an 89% risk of PCS and a low risk group with a risk of PCS of 9%. Unfortunately 50% of patients then fall into a medium risk category, where the risk is 47% for PCS. Therefore the only category that may be of use for excluding people from follow up is the low risk category, but this category was derived from only eleven patients. Therefore this study, although being the only paper to attempt the derivation of a rule is still really only of use to researchers looking to improve on their findings.

Of the remaining papers: length of post-traumatic amnesia, period of loss of consciousness, abnormal initial GCS, gender, age, positive radiological findings and various neuropsychometric tests have been advocated as being associated with an increased risk of PCS, but there is no data as to how these variables might combine as a decision rule for the safe exclusion of low risk patients from follow-up.
There is insufficient evidence for the recommendation of any decision rules that can safely exclude a patient from follow up although several high-risk variables have been reported.

All patients who have had imaging of the head (i.e. those initially deemed to be at high risk for clinically important brain injury) should be offered an outpatient appointment within two months of the injury to detect persistent problems post head injury. This appointment should be with a professional trained in the sequelae of brain injury (e.g. neurologist, clinical psychologist). In addition, all patients who seek contact with the NHS in relation to worries about their post-discharge status should be offered a similar outpatient appointment as soon as possible after the contact.

These recommendations are based on level five evidence and is considered to be a grade D recommendation.

Guidelines on the rehabilitation of adults following head injury following traumatic brain injury are currently being prepared by the British Society of Rehabilitation Medicine. These will be based on a full systematic review of the literature as well as drawing on the recommendations of existing consensus documents. The guidelines are due for publication in Autumn 2003. It is likely that these guidelines will cover the issue of patient selection for early rehabilitation and the recommendations on this subject should inform any revised version of these NICE guidelines.

It is strongly recommended that research on the early identification of head injured patients likely to suffer late sequelae become a high priority for UK research funding bodies.

8.11 Prognosis in severe head injury

A recent systematic review focusing only on severe head injuries examined evidence on early indicators of prognosis. The review found that certain variables had a high positive predictive value for poor prognosis. While this level one evidence is useful in identifying patients at highest risk for poor outcome, it is unclear what course of action should be pursued with these patients. There is little high quality evidence regarding the effectiveness or timing of neurorehabilitative interventions in these severely injured patients.

8.12 Advice about long-term problems and support services

All patients and their carers should be made aware of the possibility of long term symptoms and disabilities following head injury and should be made aware of the existence of services that they could contact should they suffer long term problems. Details of support services should be included on patient discharge advice cards. Patients should also be advised to contact their doctor about these problems.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
8.13 Communication with community services

A communication (letter or e-mail) should be generated for all patients who have attended A&E with a head injury, and sent to the patient’s GP. This letter should include details of the clinical history and examination.

A communication (letter or e-mail) should be generated for all children who received head or c-spine imaging, and sent to the relevant community paediatrician and School Medical Officer. This letter should include details of the clinical history and examination.

A communication (letter or e-mail) should be generated for all infants who received head or c-spine imaging, and sent to the relevant community paediatrician and Health Visitor. This letter should include details of the clinical history and examination.

These recommendations are based on level five evidence and are considered to be grade D recommendations.

8.14 Re-attendees

There is evidence that patients who re-attend in the days immediately after head injury are a high risk group for intracranial complications.

Patients who return to an A&E department within 48 hours of transfer to the community with any persistent complaint relating to the initial head injury should be seen by or discussed with a senior clinician experienced in head injuries, and considered for a CT scan.

This recommendation is based on level two evidence and is considered a grade B recommendation.

8.15 Rehabilitation services

Guidance on the effectiveness and timing of rehabilitation services following head injury is beyond the scope of this document. However, guidelines on the rehabilitation of adults following head injury following traumatic brain injury currently being prepared by the British Society of Rehabilitation Medicine will address these issues. These will be available in Autumn 2003.
Chapter 9. Medical radiation

9.1 Introduction

Medical radiation is one of the largest sources of radiation exposure to humans outside natural background radiation. The main diagnostic sources of radiation are CT and x-rays. Magnetic Resonance Imaging does not involve ionising radiation.

Advances in CT image quality and test speed have revolutionised radiology providing high diagnostic yield for clinicians. Consequently, the associated radiation doses are larger than the conventional x-ray and its use has steadily increased in frequency since the early 1970s. The number of CT examinations rose in the USA nearly seven times from 1981 to 1995, from 2.8 million to 20 million scans \(^1\) or up to 11% of radiographic examinations accounting for 67% of the radiation exposure.\(^2\) Similarly, the volume of CT scans in the UK in 1998 represented 4% of all radiological procedures and accounted for 40% of the collective dose to the population.\(^2,3\) Various reports from the USA claim that 4% to 11.2% of CT procedures are administered to children under the age of 15 years.\(^1,4\)

National dose surveys show significant variations in patient dose for the same CT examination, by factors of 10 to 40, due to differences in scanner design and institutional-specific examination techniques.\(^3,5\) Therefore, regardless of the diagnostic benefits of CT procedures, there is some effort to standardise methodologies and protect the patient from unnecessary exposure via reduced dosage without reduction in image quality.\(^6,7\)

9.2 Patient doses from head CT

Specific techniques of dosimetry have been developed for measuring patient radiation exposure. Patient doses can be expressed in two ways.

- Organ or tissue dose usually expressed in milligray (mGy) which reflects the energy deposited by x-rays per gram of irradiated body tissue, averaged over the particular organ or tissue.
- Effective dose usually expressed in millisieverts (mSv) which is a calculated weighted sum of organ doses that takes into account organ differences in radiosensitivity and is a useful index to compare the relative radiation risks from varying radiological procedures.

Generally, the literature shows that effective doses from head CT in adults range from 1.3 mSv to 2.3 mSv.\(^1,2,4,5,7-10\) In comparison to conventional x-ray examinations of the skull with a range of effective doses from 0.07 mSv to 0.2 mSv, CT examinations involve 5 to 32 times more radiation exposure.\(^2,10\) The eyes, thyroid and breasts typically receive doses of about 50 mGy, 2 mGy and 0.03 mGy, respectively, from a head CT scan.

Recent studies have shown that doses to infants and children from head CT examinations can be considerably higher than those for adults. For example, Huda
et al reported that the effective doses estimated for head CT examinations showed mean values of 7.6 mSv and 1.3 mSv in new-borns and adults respectively in a study of 46 patients in a hospital in the USA in 1997/98. Lowering patient dose is possible with adjustments of scan technique, tube current and filtration factors, alterations in pitch, and image reconstruction parameters.

For comparison, the average natural background radiation level in the UK gives rise to an annual effective dose of 2.2 mSv, with regional averages ranging from 1.5 mSv to 7.5 mSv per year.

9.3 CT examinations of the cervical spine

A small proportion of patients are currently deemed suitable for CT examination of the c-spine, usually carried out in conjunction with CT of the head. The mean value for the effective dose on adult patients receiving CT of the c-spine in the 1989 UK national survey carried out by the National Radiological Protection Board was 2.6 mSv. This compares to 1.8 mSv for CT of the head alone. The effective dose for c-spine CT is higher because the thyroid is directly irradiated (mean thyroid dose = 44 mGy). NRPB models indicate that the effective dose received by children and infants is higher: the increase amounts to a factor of 2.3 for newborns, a factor of 2 for 1-year olds, a factor of 1.5 for 5 year olds and a factor of 1.2 for 10 year olds. The doses involved for all age groups may now be smaller due to the introduction of multislice helical CT.

9.4 National Radiological Protection Board (NRPB) estimate summary

A summary of estimates of the effective doses received by adults, children and infants from CT and x-ray examinations of the head and c-spine are detailed in Table 9.1 below. These estimates are based on an NRPB survey and use recently published paediatric enhancement factors. These estimates assume that the same CT technique factors are used for children and adults (which has been common practice until recently).

The estimates for radiographic exams are based on typical effective doses for adults in a further NRPB survey. Effective x-ray doses for children are normally assumed to be the same as those for adults.

Table 9.1 Effective radiation doses for different imaging techniques by age group.

<table>
<thead>
<tr>
<th>Patient Age (y)</th>
<th>Effective dose (mSv)</th>
<th>Head</th>
<th>Cervical spine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Radiographs*</td>
<td>CT</td>
</tr>
<tr>
<td>0</td>
<td>0.06</td>
<td>4.1</td>
<td>0.07</td>
</tr>
<tr>
<td>1</td>
<td>0.06</td>
<td>3.6</td>
<td>0.07</td>
</tr>
<tr>
<td>5</td>
<td>0.06</td>
<td>2.7</td>
<td>0.07</td>
</tr>
<tr>
<td>10</td>
<td>0.06</td>
<td>2.2</td>
<td>0.07</td>
</tr>
<tr>
<td>Adult</td>
<td>0.06</td>
<td>1.8</td>
<td>0.07</td>
</tr>
</tbody>
</table>

* assumes 1 PA + 1 AP + 1 lateral radiograph per examination
** assumes 1 AP + 1 lateral radiograph per examination
9.5 Cancer risks

The risk of radiation-induced malignancies from a single CT exposure is difficult to assess. There have been no published prospective studies measuring incidence of cancer among CT exposed patients; however, hypothetical cancer induction rates have been calculated from the long-term follow up of populations exposed to large doses of radiation. The ICRP reports a nominal probability coefficient of 5% per Sv effective dose for the lifetime risk of fatal cancer in a population of all ages and both sexes exposed to radiation at the relatively low doses used in CT examinations. Diedrich et al use the same risk coefficient (suggesting that there will be 5 fatal cancers in every 100,000 individuals exposed to 1 mSv) and reports that risks for infants and children would be higher than the risk for adults.

More specifically, Brenner et al estimate that the lifetime cancer mortality risks from CT examinations on a one-year-old child are approximately an order of magnitude higher than the risks for CT-scanned adults. While this paper calculates a projected 500 additional cancer deaths per year in the USA from currently performed paediatric CT examinations, this only represents a 0.35% increase in the background cancer death rate. These estimates must be considered with caution, as they are based on extrapolations from mortality data of Japanese atomic bomb survivors exposed to predominantly higher radiation doses than CT patients.

As a rough guide, the NRPB estimates that the lifetime risk for radiation-induced cancer per unit dose is about twice as high in children than in adults (20-60 years old). This would put the lifetime risk of fatal cancer following exposures in childhood at about 10% per Sv effective dose, compared to about 5% per Sv for exposures to adults between 20 and 60 years old. The risks drop dramatically at ages above 60 years due to the reduced lifetime available in which these delayed effects of radiation can occur.

In summary, the best available evidence suggests that paediatric CT will result in increased lifetime risks of cancer compared to adult CT due to both the higher radiation doses currently delivered to children and their increased sensitivity to radiation-induced cancer over a longer life span.
Chapter 10. Economic evaluation

10.1 Introduction

The explicit use of economic evaluation in clinical guideline development is a recent but international phenomenon. In the USA, the Committee on Clinical Practice Guidelines has recommended that every clinical guideline include cost information for alternative patient management strategies. In the UK, the remit of NICE is to produce national clinical guidelines that address cost-effectiveness as well as clinical effectiveness.

The reasoning behind the application of economic criteria to clinical guidelines is that no health system anywhere in the world has enough resources to provide every potentially beneficial preventative, diagnostic, curative and palliative procedure. Therefore, there is a need to re-deploy resources to those procedures where the potential health gain is greatest. This requires abandoning practices that are relatively poor value for money.

There is a well-developed methodological literature for assessing the relative cost-effectiveness (value for money) of different health care procedures. There is still some debate over some of the specific methods of economic evaluation in health care but essentially there are six steps to evaluating the relative efficiency of any procedure.

1. Identify the target group (e.g. patients attending A&E with GCS > 13), the procedure to be evaluated (e.g. head CT scanning) and its alternative strategy (e.g. SXR).
2. Identify all the important health and resource outcomes that are likely to differ between the procedure and its alternative.
3. Measure the differences in identified health and resource outcomes.
4. Estimate the value of the health gain and the value of the resource use. (Resource use is valued in terms of its monetary value, its economic cost. Health gain is sometimes valued in monetary terms but more often a non-pecuniary measure such as the quality-adjusted life-year, QALY, is used).
5. Estimate the ratio of net health gain to net resource cost (e.g. the cost per QALY gained) and compare this with the ratios estimated for other commonly used health programmes to assess its relative efficiency. The estimation of net health gain and net cost requires some kind of model (such as a decision analysis) to combine probability and outcome information.
6. Consider the robustness of the cost-effectiveness estimate in terms of statistical precision and generalisability to other settings.

Ideally one would repeat each of these steps for each procedure considered within the guideline (and within each procedure, for each relevant patient subgroup). This would allow us to see for which group of patients the procedure is good value for money. In practice we are limited by the availability of data.
10.2 Methods

The guideline development group identified two main areas where the potential impact of alternative strategies could be substantial.

- Diagnosis of intracranial haematoma in patients with minor head injury
- Identifying c-spine damage in patients with head injury.

A third area, identification of patients most likely to suffer long-term sequelae, was also considered for economic evaluation. However, the lack of satisfactory clinical decision rules in this area means that this area remains an issue only on the research agenda at this time.

For both of the identified areas, a review of the literature was conducted followed by simple economic modelling of the cost-effectiveness in England and Wales of different strategies.

10.2.1 Literature review

Using the same search strategy as for the main systematic reviews (but with an additional filter to locate costing information, a search (Appendix One) was performed of:

- Medline (PubMED)
- Embase

These strategies were designed to find any economic study related to head injury. Abstracts and/or database reviews of papers found were reviewed by the health economist and were discarded if they appeared not to contain any economic data or if the focus of the paper was not imaging after trauma. Relevant references in the bibliographies of reviewed papers were also identified and reviewed.

10.2.2 Modelling of cost-effectiveness – intracranial haematoma

A cost analysis was performed for the use of CT scanning on patients who have minor/mild head injury (i.e. GCS > 12) but some loss of consciousness or post-traumatic amnesia at the time of the impact or thereafter. The reason for selecting this group is that it is assumed that those patients with a more significant loss of consciousness receive CT scanning automatically or are referred to neurosurgery. It is assumed that those who do not experience loss of consciousness or post-traumatic amnesia will not receive CT scanning. These assumptions mirror the methods used to derive the Canadian CT-head rule.

Four alternative strategies were selected for the model (Table 10.1). The first is the original UK guidelines for surgeons (the ‘Harrogate guidelines’). The second and
third are the Canadian head rules, which avoid SXR, but allow greater access to CT scanning. Patients with a negative CT scan would be discharged. The fourth strategy is comprehensive scanning and admission of all patients, essentially what happens in the US system.

Table 10.1 - Description of different strategies for the target group

<table>
<thead>
<tr>
<th>Indications for test</th>
<th>SXR</th>
<th>24 hour admission</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Current UK system</td>
<td>All</td>
<td>headache, vomiting or other neurological indication</td>
<td>skull fracture or deterioration in 24 hours</td>
</tr>
<tr>
<td>2. Canadian CT Head 5-rule</td>
<td>None</td>
<td>+ve CT scan</td>
<td>suspected fracture (open, depressed, basal), age ≥ 65 years, GCS = 13-14 at 2 hours, 2+ vomiting episodes</td>
</tr>
<tr>
<td>3. Canadian CT Head 7-rule</td>
<td>None</td>
<td>+ve CT scan</td>
<td>As for 5-rule but also CT if pre-impact amnesia &gt; 30mins or dangerous mechanism</td>
</tr>
<tr>
<td>4. US system</td>
<td>None</td>
<td>All</td>
<td>All</td>
</tr>
</tbody>
</table>

The expected cost and cost per intracranial haematoma detected for each strategy was calculated on the basis of the expected usage of SXR, head CT scan and 24 hour observation. It was not possible to quantify differences in health outcomes and other cost outcomes (Table 10.2, outcomes 4-9).

Table 10.2 - Health and resource consequences of Canadian CT head rule versus current system in England and Wales.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Net social effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definite or likely outcomes</td>
<td></td>
</tr>
<tr>
<td>1. Reduced use of SXR</td>
<td>+ve</td>
</tr>
<tr>
<td>2. Increased use of CT scanning</td>
<td>-ve</td>
</tr>
<tr>
<td>3. Reduced inpatient stay</td>
<td>+ve</td>
</tr>
<tr>
<td>Possible outcomes</td>
<td></td>
</tr>
<tr>
<td>4. Improved neurosurgical outcomes</td>
<td>+ve</td>
</tr>
<tr>
<td>5. Increased incidence of cancer as a result of increased radiation exposure</td>
<td>-ve</td>
</tr>
<tr>
<td>6. Change in health service resource use as a result of 4 and 5.</td>
<td>+ve/-ve</td>
</tr>
<tr>
<td>7. Change in patient/family resource use as a result of 3</td>
<td>+ve/-ve</td>
</tr>
<tr>
<td>8. Change in patient/family resource use as a result of 4 and 5</td>
<td>+ve/-ve</td>
</tr>
<tr>
<td>9. Reduction in litigation costs</td>
<td>+ve</td>
</tr>
</tbody>
</table>

NB – Any increase in resource use has a negative effect for society because those resources can’t then be used for some other beneficial purpose.
Usage figures were derived from Nee et al \(^5\) for the Harrogate model and from Stiell et al \(^6\) for the Canadian rules (Table 10.3). For the US model, usage was determined by the model definition.

### Table 10.3 – Proportion of target group receiving each test

<table>
<thead>
<tr>
<th>Proportion of target group</th>
<th>SXR £26ea</th>
<th>24 hour admission £200ea</th>
<th>CT £160ea</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Current UK system(^a)</td>
<td>100%</td>
<td>26%</td>
<td>4%</td>
</tr>
<tr>
<td>4. Canadian CT Head 5-rule</td>
<td>0%</td>
<td>8%(^*)</td>
<td>32%</td>
</tr>
<tr>
<td>3. Canadian CT Head 7-rule</td>
<td>0%</td>
<td>8%(^*)</td>
<td>54%</td>
</tr>
<tr>
<td>4. US system</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

* Stiell et al\(^6\) propose discharging patients that have a negative CT scan, although they are only half way through their validation study, which applies this strategy. This figure is based on their prevalence of complications.

Stiell et al have not yet put their model into practice, therefore the admission rate figure is provisional. For this model it was assumed that only those with a positive CT scan (ICH or other complication) would be admitted. Another problem was that the study that presented data on the Canadian rules had already excluded patients without any loss of consciousness or post-traumatic amnesia, whereas the UK paper had not. This problem was tackled by assuming that patients in the UK study who were discharged without a SXR or CT scan were also very low risk (i.e. had no loss of consciousness or post-traumatic amnesia).

### 10.2.3 Modelling of cost-effectiveness – c-spine injuries

We compared the cost of the two alternative strategies identified as being derived using relatively high quality methods:

- NEXUS study rule \(^7\)
- Canadian c-spine rule \(^8\)

These systems evaluate all patients with head trauma.

The expected cost for each strategy was calculated on the basis of the expected usage of c-spine x-ray, and c-spine CT scan. It was not possible to quantify differences in health outcomes and other cost outcomes (Table 10.4, outcomes 3-8). Usage figures were derived from the original studies. In the case of the Canadian c-spine rule, there has not been a validation study hence the figures are from the original derivation study. It was assumed that, for both strategies, 39% of x-rays are inadequate \(^7\) and that these are followed up with a CT scan.

### Table 10.4 - Outcomes from c-spine scanning
1. Use of c-spine x-ray
2. Use of c-spine CT scanning
3. Number of surgical interventions resulting from detection of fractures
4. Incidence of paralysis
5. Incidence of cancer as a result of radiation exposure
6. Change in health service resource use as a result of 4 and 5.
7. Change in patient/family resource use as a result of 4 and 5
8. Change in litigation costs

10.2.4 Unit costs

The unit costs of SXR and head CT scan were taken from the published literature (Table 10.5). HEED and NHS EED were searched. This was not restricted to the head injury context, as the cost of the test should be identical or similar regardless of the setting. It is worth noting that any search for published unit costs is likely to be relatively insensitive because a unit cost is usually only a small component of an economic evaluation and hence is unlikely to get a mention in the abstract or MeSH headings. The search was limited to studies conducted in the UK NHS because staff costs and overheads vary considerably between health systems. Abstracts and/or database reviews of the papers found were reviewed by the health economist and were discarded if it appeared not to contain a unit cost for any of the tests under study. Costs extracted were inflated to 2001 prices using the health component of the Retail Prices Index.

Table 10.5 - Unit cost estimates for the UK NHS

<table>
<thead>
<tr>
<th></th>
<th>Cost per patient tested (2001 UK£):***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>SXR*</td>
<td>14</td>
</tr>
<tr>
<td>Cranial CT scan*</td>
<td>60</td>
</tr>
<tr>
<td>24 hour observation**</td>
<td>150</td>
</tr>
</tbody>
</table>

* Unit costs extracted from published literature.11-13,19-22

** Cost per day of an inpatient stay for a ‘Head injury without significant brain injury: uncomplicated’ from the NHS Reference Cost 2000 database (n = 153,000 inpatient days) – 25th, 50th and 75th centiles.

*** Costing methods of studies may vary but all include staff time, equipment cost and consumable cost, although not necessarily overheads.

Given the lack of relevant data c-spine x-ray and c-spine CT scans were assumed to cost the same as head x-ray and head CT scans respectively.

A unit cost of 24-hour observation was estimated approximately using the median cost per day of an inpatient stay for a ‘Head injury without significant brain injury: uncomplicated’ from the NHS Reference Cost 2000 database. This was extracted from the NHS Reference Costs 2000 database. The NHS reference cost database9 contains accounting cost data from every NHS hospital trust. Each trust reports an average cost per hospital episode, categorised by type of visit (e.g. outpatient, elective inpatient, etc) clinical specialty and Healthcare Resource Group (HRG). The NHS Reference cost 2000 database contains information for 69.4 million hospital episodes amounting to 88% of annual expenditure on services by NHS hospitals. Accounting practices do vary between hospitals but the costs should reflect the full
cost of the service (including direct, indirect and overhead costs), as described in the NHS Costing Manual.\textsuperscript{10}

Sensitivity analyses were conducted to test the sensitivity of the results to the model parameters:
- for the unit costs, the range of estimates from the literature was used,
- for the cost of an inpatient day, the inter-quartile range from the NHS Reference Costs database was used, and
- for the probabilities, the confidence intervals were used.

\textbf{10.3 Diagnosis of intracranial haematoma in patients with a minor/mild head injury}

CT represents the gold standard in the diagnosis of intracranial haematoma following head injury. However, the number of CT scanners and trained staff in the NHS is limited and the cost of testing substantial. Therefore CT scanning in the NHS is currently restricted mainly to those with significant loss of consciousness (either on arrival or after deterioration) and those with a skull fracture, as diagnosed through SXR. The question arises as to whether CT scanning would be cost-effective (i.e. value for money) if extended to a larger group of patients.

\textbf{10.3.1 Literature review}

Six studies have evaluated the overall impact of different diagnostic testing strategies for patients with minor/mild head injury. The UK studies date back to the early 1980s (pre-CT scanning) and advocate that both SXR and inpatient observation be reduced to save costs.\textsuperscript{11-13}

Three overseas studies have compared CT scanning with alternative strategies. Ingebrigtsen and Romner\textsuperscript{14} found that inpatient observation was not necessary with CT. Therefore CT screening was less costly than SXR screening in Norway because it reduced inpatient stays. Shackford et al\textsuperscript{15} and Stein et al\textsuperscript{16} had already come to the same conclusion for the USA. However, Stein et al also considered the potential use of x-ray screening \textit{without} inpatient observation and not surprisingly found this to be the least costly strategy.

Essentially they have concluded that a system of CT scanning high risk patients followed by discharge after a negative CT scan is less costly than admitting and SXR for all of these patients. However, this comparison is not strictly relevant to the context of England and Wales because the current system does not admit all patients.

The published evidence from the six studies is not ideal because:
- the resource use and cost for CT scanning is not specific to the UK NHS context or is dated; and
- they have sought to quantify and cost outcomes 1-3 only. For example, the studies did not measure the cost savings and health gain associated with early diagnosis. Stein et al suggested that for those patients who are not diagnosed
early there are lost wages and increased costs relating to inpatient stay, rehabilitation, treatment, medication and orthotic devices.

10.3.2 Cost-effectiveness model – imaging of the head

Using the unit costs and frequencies of testing, the cost per patient of each strategy is shown in Table 10.6. The least cost strategy is the 5-rule Canadian CT Head rule. Although the cost of CT scanning is higher than for the current UK system, the extra cost is more than offset by the reduction in SXRs and admissions.

Table 10.6 – Cost per patient for each strategy

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Component costs (£)</th>
<th>Total cost (£)</th>
<th>Cost per ICH detected (£)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Current UK system</td>
<td>26</td>
<td>51</td>
<td>7</td>
</tr>
<tr>
<td>2. Canadian CT Head 5 point rule</td>
<td>0</td>
<td>18</td>
<td>52</td>
</tr>
<tr>
<td>3. Canadian CT Head seven point rule</td>
<td>0</td>
<td>18</td>
<td>87</td>
</tr>
<tr>
<td>4. US system</td>
<td>0</td>
<td>200</td>
<td>160</td>
</tr>
</tbody>
</table>

Assuming prevalence of intracranial haematoma (ICH) is 1.4% and assuming all strategies are 100% sensitive.

These results would suggest that moving from the current system to the five point Canadian head rule could actually save the NHS money (although the seven point rule, which scans more patients, is likely to add to costs). It would require investment in additional CT scanning facilities but the freeing up of ward space and x-ray capacity would make up for this.

These results were, however, sensitive to the unit costs (Table 10.7). For example, the seven point rule could potentially save money if we use the lower estimate for the cost of a CT scan and the higher estimate of a cost of an inpatient day.

Table 10.7 - Sensitivity analysis for head CT scanning rules

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Incremental cost per patient (£) - Canadian 7 point rule compared with current UK system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>20.84</td>
</tr>
<tr>
<td>Sensitivity to unit costs*</td>
<td>-63.22, 61.18</td>
</tr>
<tr>
<td>Sensitivity to proportion of patients scanned</td>
<td>11.52, 30.16</td>
</tr>
<tr>
<td>Sensitivity to both unit costs and proportions</td>
<td>-72.34, 70.22</td>
</tr>
</tbody>
</table>

* Lower limit: High SXR cost (£45ea), High admission cost (£290ea), Low CT cost (£60ea)
Upper limit: Low SXR cost (£14ea), Low admission cost (£150ea), High CT cost (£200ea)

This cost analysis was limited because the frequency of testing and admission for each strategy could only be estimated approximately given the currently available data. The Canadian head rule is only less costly than the current UK system because it is assumed that it reduces the number of admissions. In fact Stiell et al 6
have not yet put their model into practice, therefore the admission rate figure is provisional. For this model it was assumed that only those with a positive CT scan (ICH or other complication) would be admitted. If the number of admissions were somewhat higher then this strategy would not be the least cost strategy. Assuming all other parameters in the model remain the same, the five point Canadian head rule is least cost if it reduces inpatient admissions by at least 37%. The seven point Canadian head rule appears to be more expensive even if admissions were entirely eliminated.

Another problem was that the study that presented data on the Canadian rules had already excluded patients without loss of consciousness or post-traumatic amnesia, whereas the UK paper had not—this problem was tackled by assuming that patients who were discharged without a SXR. Furthermore the analysis did not include outcomes 4-8 from Table 10.2.

10.3.3 Health outcomes (4 and 5)

A strategy that increases NHS costs would be economically justified if there were associated health gains. Intuitively, we might expect surgical outcomes to improve if intracranial haematomas (ICHs) are detected earlier. There is no direct evidence that a strategy of CT scanning can improve neurosurgical outcomes although there is some evidence that outcomes have been improved in patients with more serious head injuries.17

Any health gains associated with detection could be partially offset by increased cancer risk. There is no direct evidence that exposure to medical x-rays does increase the incidence of cancer, however, there is a general association between radiation and genetic mutation and it is clear that the exposure level is considerably higher with CT scanning than with conventional SXR (see Chapter 9).

10.3.4 Other health service costs (6)

The change in health outcomes just mentioned would lead to considerable changes in health service resource use for the particular patients affected. However in both cases the net change in health service costs could go up or down. For example, if an improvement in neurosurgical outcome lead to more people surviving but those that survive require long term care for chronic brain injury then costs would increase. Alternatively if both mortality and disability were reduced then long-term costs are likely to be reduced. However, whichever the direction the change is in, the average change in costs per patient scanned is likely to be small given the low likelihood of a change in health outcome.

10.3.5 Patient costs (7&8)

The costs (time, lost income, medication purchased, etc) to patients and their families associated with changes in health outcome could be considerable. As with health service costs we could not be certain what the net effect would be for the family. Again when averaged across all patients these cost changes could be quite small because the incidence of these changes in outcomes will be small.
There may be substantial costs associated with the decision to admit but these are likely to differ according to the situation of the family. For example, if a parent is admitted then there might be a need for child-minders but on the other hand the act of regular observation at home is costly in itself and families might find it easier if this burden were undertaken by the hospital.

10.3.6 Litigation costs (9)

It has been suggested that litigation might be reduced if more people were scanned. However, Bramley et al 18 have estimated that only one in 10,000 patients subsequently turn out to have an IH after being discharged without a CT. Hence not every occasion would result in a lawsuit therefore the potential costs saved per patient screened is likely to be small. Current medico-legal costs for the NHS associated with acute head injuries are being sought from the NHS Legal Authority and it is hoped they will inform later versions of this guideline. However, it should be born in mind that successful litigation usually arises out of organisations not abiding by guidelines, and, given that other guidelines (e.g. the ‘Harrogate’ guidelines) are currently in circulation, this is clearly still a risk whether or not the current guidelines are implemented.

10.4 Identifying cervical spine damage in patients with head injury

Table 10.4 identifies the resource and health outcomes that could differ between different diagnostic strategies.

10.4.1 Literature review

There are three cost-effectiveness studies in this area:

- Keneriya et al 23 estimated that five view x-ray could save $24 per patient scanned compared with three view because it reduced the number of subsequent CTs associated with inadequate x-rays by 48%.
- Tan et al 24 estimated the cost-effectiveness of CT scan after inadequate x-ray. They found a cost of $16,900 per potentially (or definitely) unstable fracture and $50,600 per definitely unstable fracture. This is cost-effective given the consequences of paralysis.
- Blackmore et al 25, using test sensitivities pooled from the published literature, compared CT scanning of the c-spine with conventional c-spine x-ray. Using their own risk rating scale, they found CT scanning to be a cost-effective strategy ($16,000 per quality-adjusted life-year gained) for the ‘high’ and ‘moderate’ risk groups (high energy mechanism and age < 50 or moderate energy mechanism and age > 50) but not for the low risk group ($84,000 per QALY gained). Unlike the other studies, incorporated into these figures are the costs and morbidity associated with paralysis.
- In addition, two more studies estimated the costs that could be saved by moving from current practice at a particular institution to a particular scanning protocol.26,27
The above studies are not strictly relevant to the context of England and Wales, not least because the unit costs and the patient groups used in the studies are not from the UK. Furthermore they only attempted to include outcomes 1 and 2 (and in the case of Blackmore et al 4 and 6 as well) and crucially do not address the long-term effects of medical radiation.

The Blackmore analysis suggests for a patient group that is at particularly high risk of paralysis, c-spine CT could be preferable to x-ray by both improving health outcomes and lowering costs, even taking into account the large effective doses associated with c-spine CT radiation. This would be very difficult to model given the lack of empirical evidence on the long-term effects of this medical radiation. It was the consensus of the GDG that the benefits from CT scanning of the c-spine do not obviously outweigh the risks.

10.4.2 Cost-effectiveness model – imaging of the cervical spine

We conducted our own tentative cost analysis comparing the NEXUS and the Canadian c-spine rules. We estimated that the Canadian rule could save about £26 per trauma patient (Table 10.8).

Table 10.8 – Comparison of the Canadian and NEXUS c-spine rules

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Proportion of head trauma patients receiving test</th>
<th>Cost of testing (£) per head trauma patient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X-ray</td>
<td>CT</td>
</tr>
<tr>
<td>Canadian</td>
<td>58.2%</td>
<td>22.8%</td>
</tr>
<tr>
<td>NEXUS</td>
<td>87.4%</td>
<td>34.2%</td>
</tr>
<tr>
<td>Increment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The assumption of CT scans for all inadequate x-rays may over-estimate the actual cost savings; if we ignore them then the cost-savings are £8 per patient scanned. Sensitivity ranges are presented in Table 10.9.

Table 10.9 - Sensitivity analysis for c-spine scanning rules

<table>
<thead>
<tr>
<th></th>
<th>Incremental cost per trauma patient (£) of NEXUS rule compared with Canadian c-spine rule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X-ray costs only</td>
</tr>
<tr>
<td>Baseline estimate</td>
<td>7.58</td>
</tr>
<tr>
<td>Sensitivity to unit costs</td>
<td>4.08, 13.13</td>
</tr>
<tr>
<td>Sensitivity to proportions tested</td>
<td>7.23, 7.94</td>
</tr>
<tr>
<td>Sensitivity to both unit costs and proportions</td>
<td>3.89, 13.73</td>
</tr>
</tbody>
</table>

The Canadian c-spine rule could save valuable health service resources but it is yet to be validated and if it was found to be less sensitive it might not be the most cost-effective strategy due to the morbidity and high health service costs associated with paralysis. This cost analysis was limited because of the use of overseas data and
the simplified assumptions regarding dealing with inadequate x-rays. Furthermore the analysis did not include outcomes 3-8 from Table 10.4.

10.5 Discussion/conclusions

A simple cost model demonstrates that some strategies that increase head CT scanning could potentially reduce costs if patients that have a negative scan are discharged without admission. However, other strategies that lead to a very high CT scanning rate are likely to increase health service costs. The imprecision of the data available (unit costs and test frequencies) means that it is not possible to identify with any degree of certainty those specific strategies that will increase cost and those that will decrease cost. Furthermore there are health outcomes and some additional changes to resource use that cannot be quantified using currently available data.

Table 10.10 (below) summarises the estimated changes in imaging and admission volumes and cost in England and Wales as a result of these guidelines. This is based on Tables 10.3, 10.6 and 10.8 and assumes an incidence of 700,000 head injury attenders to A&E per year.

We would like to emphasise the tentativeness of these estimates. There is uncertainty over these figures for a number of reasons. Data was taken from four different sources to estimate the number of scans (currently and with the new system). Various assumptions had to be made to make the denominator of the estimates from these studies comparable. Some of the evidence was not from a UK population.

Clearly the fall in SXRs is likely to be an overestimate, as some SXRs may still have to take place for penetrating injuries, etc. The reduction in inpatient observation is also uncertain. This assumes that clinicians are able to discharge patients who have had a negative CT scan. This will certainly not be the case for patients who have other comorbid traumatic symptoms.

<table>
<thead>
<tr>
<th>Table 10.10 – Imaging and admission volumes and costs England and Wales associated with different clinical decision rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number per year (000)</td>
</tr>
<tr>
<td>-----------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Head</strong></td>
</tr>
<tr>
<td>SXR</td>
</tr>
<tr>
<td>Head CT</td>
</tr>
<tr>
<td>24-hr Obs</td>
</tr>
<tr>
<td><strong>C-Spine</strong></td>
</tr>
<tr>
<td>C-S XR</td>
</tr>
<tr>
<td>C-S CT</td>
</tr>
<tr>
<td><strong>All</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
The Canadian head CT rule, adopted by the consensus of the GDG is expected to increase costs, however this result was sensitive to the unit costs incorporated into the model. If costs are increased then they are likely to be accompanied by improvements in quality of care. In the short term this will mean fewer patients being diagnosed on 'deterioration', patients getting reassurance sooner rather than later and possibly even improvements in long-term outcomes (although this is speculative). If patient outcomes were improved than this in turn might lead to additional cost-savings (again speculative). It was the decision of the GDG that the potential benefits of adopting this rule are likely to outweigh the potential costs.

The NEXUS c-spine rule and the Royal College of Radiologists (RCR) guidelines appear to be almost identical. Given this, on the basis of a simple cost model, the adoption of the Canadian c-spine rule could save valuable health service resources. This rule is yet to be validated, however, and if it was found to be less sensitive it might not be the most cost-effective strategy due to the morbidity and high health service costs associated with paralysis. On the other hand, the thyroid is known to be susceptible to radiation damage and strategies that reduce the need for radiological examination of the neck may reduce subsequent morbidity and health service cost.

Our simple analyses estimated an additional scanning cost of £21 per head trauma patient associated with adopting the Canadian head CT and a cost saving of £26 associated with adopting the Canadian c-spine rule. This suggests a combined impact of £5 saved per patient and the saving would be greater if a combined CT scan of the neck and head were performed. For England and Wales, assuming an incidence of head injury of around 700,000 cases a year, of which 54% satisfy the criteria for scanning, a modest saving of £1.9m that could be reinvested in the health service would result. However, we should be very cautious about this figure given that the sensitivity ranges are consistent with a substantial increase in cost as well as a cost saving. Furthermore the long-term impact of changing imaging strategies on health outcomes and health service costs is even less certain. Staff shortages in radiology mean that implementation of these changes could take some time or else use up extra resources. Another reason why these cost savings might not be realised in the short term is that they are likely to require investment in new CT scanning equipment.

It is probable that we have not taken into account fully the implementation costs of the guideline. To some extent this is true, as our remit, does not include the details of implementation. For example, we acknowledge that full implementation of the guideline will require staff training, the cost of which we have not been in a position to quantify.

It is also possible that the costs incorporated into our cost analyses do not reflect the real costs of the services. For example, the increased utilisation of CT scanners may necessitate the purchase of additional scanners. The capital cost of CT scanners should in principle be incorporated into the unit costs that we have used in our cost-effectiveness model, as is the convention in NHS costing practice. The unit costs that we used, however, were taken from the published literature and therefore we cannot be sure about precisely how they were calculated. There is also a
possibility of the expansion of out of hours practice, which may push up the unit cost of scanning. The shortage of radiology and radiography staff, especially those with appropriate experience in CT scanning of the head, may again mean that the real cost of increasing CT scanning is greater than our calculations would suggest or at least that implementation will have to be delayed.

One issue raised throughout the guideline consensus process was the need for specifically trained staff. Achieving this goal, nationally, could require substantial resources, especially when shortages in specialist staff (e.g., radiographers) are already constraining the system.\textsuperscript{28}

We have suggested a number of reasons in the guideline document why the cost savings we have predicted might not occur. These include:

- inpatient observation may not be reduced despite the increase in CT scanning;
- c-spine CT might be quite rare at present and therefore the reductions won’t take place;
- some SXRs will still have to take place for penetrating injury;
- we have postulated that the similarity between the NEXUS guidelines and those of the RCR suggest that the NEXUS study represents current practice for c-spine imaging in the UK. If this is not the case then a move to the Canadian c-spine rule might not lead to cost savings.

It is clear that the long-term morbidity associated with injury to the head and c-spine and the lack of evidence concerning suitable rehabilitation is a major problem. Not only does it reduce the quality of life for these individuals but also it places a substantial burden on society in general through time off work and social security payments.\textsuperscript{29} Hence the development of effective rehabilitation programmes should be placed high up the research agenda.

The other elements of the guideline are probably more conservative and therefore the overall impact on health service resources is probably small although it remains uncertain.
7. Swann IJ, Teasdale GM. Current concepts in the management of patients with so-called 'minor' or 'mild' head injury. Trauma 1999; 1: 143-5.


References – Chapter 2

References – Chapter 3

References – Chapter 4

3. Sethi D, Kwan I, Roberts I, Bunn F (on behalf of the WHO Pre-Hospital Trauma Care Steering Committee). Advanced trauma life support training for ambulance crews. Cochrane Library 2001; 4: 1-9.

References – Chapter 5


References – Chapter 6


References – Chapter 7

References – Chapter 8

References – Chapter 9
11. Wall BF. Personal communication from the National Radiological Protection Board 2002.

References – Chapter 10


Appendix 1. Search strategies

Systematic review of indications for computed tomography of the head

Medline search

1 Craniocerebral-Trauma/
2 Head-Injuries-Penetrating/
3 exp Head-Injuries-Closed/
4 exp Brain-Injuries/
5 (cerebral trauma).tw.
6 (craniocerebral trauma or cranio-cerebral trauma).tw.
7 (head injur$ or brain injur$).tw.
8 (brain trauma or head trauma).tw.
9 Skull-Fractures/
10 Skull-Fracture-Depressed/
11 Skull-Fracture-Basilar/
12 (skull fracture$).tw.
13 exp Intracranial-Hemorrhage-Traumatic/
14 (intracranial injur$ or intracranial hematoma$ or intracranial haematoma$ or intracranial hemorrhage$ or intracranial haemorrhage$ or epidural hematoma$ or epidural haematoma$ or epidural hemorrhage$ or epidural haemorrhage$ or subdural hematoma$ or subdural haematoma$ or subdural hemorrhage$ or subdural haemorrhage$ or extradural hematoma$ or extradural haematoma$ or extradural hemorrhage$ or extradural haemorrhage$).tw.
15 (brain lesions or intracranial lesions or neurological lesions).tw.
16 (cerebral oedema$ or cerebral edema$ or brain oedema$ or brain edema$).tw.
17 or/1-12
18 or/13-16
19 or/1-13
20 Tomography-X-Ray-Computed/
21 (compute$ tomograph$ or ct).tw.
22 Tomography-X-Ray/
23 Radiography-/
24 (skull radiograph$ or skull xray$ or skull x-ray$).tw.
25 or/20-24
26 (((glasgow coma scale or gcs) near (13 or 14 or 15)) or mild or minor or minimal).tw.
27 Animal/ not (Human/ and Animal/)
28 (biography or comment or editorial or letter or news).pt.
29 27 or 28
30 (19 and 25 and 26) not 29
31 (17 and 18 and 25) not 29
32 29 or 30
33 limit 32 to yr=1990-2002

Embase search
head-injury/
exp brain-injury/
skull-injury/
skull-fracture/
skull-base-fracture/
(craniocerebral trauma or cranio-cerebral trauma or cerebral trauma).tw.
(brain trauma or head trauma).tw.
(head injur$ or brain injur$).tw.
(skull fracture$).tw.
or/1-9
exp brain-hematoma/
epidural-hematoma/
brain-hemorrhage/
(intracranial injur$ or intracranial hematoma or intracranial haematoma$ or intracranial hemorrhage$ or intracranial haemorrhage$).tw.
(epidural hematoma$ or epidural haematoma$ or epidural hemorrhage$ or epidural haemorrhage$ or extradural hematoma$ or extradural haematoma$ or extradural hemorrhage$ or extradural haemorrhage$).tw.
(subdural hematoma$ or subdural haematoma$ or subdural hemorrhage$ or subdural haemorrhage$).tw.
(brain lesions or intracranial lesions or neurological lesions).tw.
(cerebral edema or cerebral oedema or brain edema or brain oedema).tw.
or/11-18
radiography/
skull-radiography/
computer-assisted-tomography/
brain-tomography/
(compute$ tomograph$ or ct).tw.
skull radiograph$ or skull xray$ or skull x-ray$
or/20-25
((glasgow coma scale or gcs) near (13 or 14 or 15)) or mild or minor or minimal
Animal/ not (Human/ and Animal/)
(letter or comment or editorial).pt.
or/28 or 29
(10 and 26 and 27) not 30
(10 and 19 and 26) not 30
31 31 or 32
34 limit 33 to yr=1990-2002

Systematic review for indications for imaging of the cervical spine

Medline search

radiography/ or exp neuroradiography/
Spine/ra [Radiography]
exp Cervical Vertebrae/ra [Radiography]
Neck/ra [Radiography]
Embase search

Cervical Spine Radiography/ spine/ or cervical spine/
Neck/
(neck or spine or spinal).tw.
(radiograph$ or xray$ or x-ray$).tw.
1 or ((2 or 3 or 4) and 5)
spine injury/ or exp cervical spine injury/ or cervical spine fracture/ or cervical spine dislocation/
spinal cord injury/ or exp cervical spinal cord injury/
neck injury/ or exp whiplash injury/
whiplash.tw.
((trauma or injur$) adj25 (neck or spine or spinal)).tw.
or/7-10
cervical.mp.
(letter or comment or editorial).pt.
(Animal/ not (Human/ and Animal/))
14 or 15
(6 and 12 and 13) not 16
limit 17 to yr=1990-2002

Medline

Cranio cerebr al Trauma/
Head Injuries, Penetrating/
exp Head Injuries, Closed/
exp Brain Injuries/
(cerebral trauma or cranio cerebr al trauma or cranio-cerebral trauma).tw.
(head injur$ or brain injur$ or brain trauma or head trauma).tw.
skull fractures/ or skull fracture, basilar/ or skull fracture, depressed/
skull fracture$.tw.
9 exp intracranial hemorrhage, traumatic/
10 or/1-9
11 ((glasgow coma scale adj ("13" or "14" or "15")) or (gcs adj ("13" or "14" or "15"))).tw.
12 (minor or mild or minimal or trivial).tw.
13 or/11-12
14 prognosis/ or exp treatment outcome/
15 incidence/ or exp mortality/ or follow-up studies/
16 mortality.sh.
17 (prognosis$ or predict$ or course).mp.
18 or/14-17
19 animal/ not (animal/ and human/)
20 (comment or letter or editorial).pt.
21 19 or 21
22 (10 and 13 and 18) not 21
23 limit 21 to yr=1990-2002

Embase
1 Head Injury/
2 exp Brain Injury/
3 skull injury/ or skull fracture/ or skull base fracture/
4 (craniocerebral trauma or cranio-cerebral trauma or cerebral trauma).tw.
5 (head injur$ or brain injur$ or brain trauma or head trauma).tw.
6 or/1-5 (47310)
7 ((glasgow coma scale adj ("13" or "14" or "15")) or (gcs adj ("13" or "14" or "15"))).tw.
8 (minor or mild or minimal or trivial).tw.
9 or/7-8
10 exp "Prediction and Forecasting"/
11 exp Treatment Outcome/
12 incidence/ or exp mortality/
13 exp Follow Up/
14 (prognosis$ or predict$ or course).mp.
15 or/10-14
16 (editorial or comment or letter).pt.
17 (Animal/ not (Human/ and Animal/))
18 16 or 17
19 (6 and 9 and 15) not 16

Systematic review of radiation risks associated with computed tomography of the head

Medline
1 Tomography, X-Ray Computed/ or (compute$ tomograph$ or ct).tw.
2 exp Radiation Injuries/
3 exp Neoplasms/
4 (neoplas$ or cancer or tumor$ or tumour$ or carcinoma$ or adenocarcinoma$).mp.
5 or/3-4
6 exp Radiation/
7 Radiation Dosage/
8 (radiation adj5 (dose or dosage or doses)).tw.
9 or/6-8
10 exp Risk/
11 exp Cohort Studies/
12 (odds and ratio).mp.
13 (relative and risk).mp.
14 (case and control).mp.
15 risk.mp.
16 or/13-18
17 (biography or comment or editorial or letter or news).pt.
18 (Animal/ not (Human/ and Animal/))
19 10 or 11
20 (1 and (2 or (5 and 9 and 16))) not 19
20 limit 20 to yr=1990-2002

Embase

1 exp Computer Assisted Tomography/
2 (compute$ tomograph$ or ct).tw.
3 or/1-2
4 exp Radiation/
5 radiation/ or ionizing radiation/
6 exp Radiation Injury/
7 exp Radiation Exposure/
8 Radiation Dose/
9 Radiation Response/
10 (radiation adj (dose or dosage or doses or expos$)).tw.
11 or/4-10
12 exp Neoplasm/
13 (neoplas$ or cancer or tumour$ or tumor$ carcinoma$ or adenocarcinoma$).tw.
14 or/12-13
15 Cancer Risk/
16 Radiation Carcinogenesis/
17 or/18-19
18 risk/ or risk assessment/ or risk factor/
19 Cohort Analysis/
20 (odds and ratio).mp.
21 (relative and risk).mp.
22 (case and control).mp.
23 or/21-25
24 (letter or comment or editorial).pt.
24 (Animal/ not (Animal/ and Human/))
25 or/15-16
26 (3 and (17 or (11 and 14 and 23))) not 26
27 limit 27 to yr=1990-2002

Head Injury Search Terms for HEED and NHS Economic Evaluation Database

NHS Economic Evaluation Database
1. explode 'Craniocerebral-Trauma' (MESH term)
2. cerebral trauma
3. craniocerebral trauma or cranio-cerebral trauma
4. head injur* or brain injur*
5. brain trauma or head trauma
6. skull fracture*
7. or/1-6

This gives 63 references.

HEED
Similar search strategy used without the exploded MESH terms

Cervical Spine Search Terms for HEED and NHS Economic Evaluation Database

NHS Economic Evaluation Database
1. neuroradiography
2. radiograph* or xray* or x-ray*
3. spine or spinal or neck or cervical vertebrae or cervical spine
4. 1 or (2 and 3)

This gives 31 references

HEED
Similar search strategy used

Medline and Embase used the same strategies for each clinical question, the cost papers being filtered from the search using the cost filter: cost OR costs OR cost-effective OR cost-effectiveness OR costeffective OR costeffectiveness OR cost-benefit OR benefit-cost OR cost-effect* OR costeffect* OR cost-benefit* OR benefit-cost* OR benefitcost* OR QALY OR life-year OR “life year”
Appendix 2. Suggested written discharge advice card for patients over 12 years

We think that it is alright for you to leave hospital now. We have checked your symptoms and you seem well on the road to recovery. When you get home it is very unlikely that you will have any further problems. But, if any of the following symptoms do return, we suggest you come back, or get someone to bring you back to your nearest hospital A&E Department as soon as possible:

- any confusion (not knowing where you are, getting things muddled up)
- any drowsiness (feeling sleepy) that goes on for longer than one hour when you would normally be wide awake
- any problems understanding or speaking
- any loss of balance or problems walking
- any weakness in one or more arms or legs
- any problems with your eyesight
- very painful headache that won’t go away
- any vomiting – getting sick
- any fits (collapsing or passing out suddenly)
- clear fluid coming out of your ear or nose

Things you shouldn’t worry about

You may feel some other symptoms over the next few days which should disappear in the next two weeks. These include a mild headache, feeling sick (without vomiting), dizziness, irritability or bad temper, problems concentrating or problems with your memory, tiredness, lack of appetite or problems sleeping. However, if you feel very concerned about any of these symptoms, you should go and see your own doctor to talk about them. If these problems do not go away after two weeks, you must go and see your doctor. We would also recommend that you seek a doctor’s opinion about your ability to drive a car or motorbike.

Things that will help you get better

If you follow this advice you should get better more quickly and it may help any symptoms you have to go away:

- DO have plenty of rest and avoid stressful situations
- DO NOT take any alcohol or drugs
- DO NOT take sleeping pills, sedatives or tranquilisers unless they are given by a doctor
- DO NOT play any contact sport (e.g. football) for at least three weeks without talking to your doctor first
- DO NOT drive a car, motorbike or bicycle, operate machinery or return to work unless you feel you have completely recovered

Long-term problems
Most patients recover quickly from their accident and suffer no long-term problems. However, some patients only develop problems after a few weeks or months. If you start to feel that things are not quite right (e.g. memory problems, not feeling yourself), then please contact your doctor as soon as possible so that we can check to make sure you are recovering properly.
Appendix 3. Suggested written discharge advice card for parents

We think that it is alright for your child to leave hospital now. We have checked their symptoms and they seem well on the road to recovery. When you get them home it is very unlikely that they will have any further problems. But, if any of the following symptoms do return, we suggest you bring them back to their nearest hospital A&E Department as soon as possible:

- any confusion (not knowing where they are, getting things muddled up)
- any drowsiness (feeling sleepy) that goes on for longer than one hour when they would normally be wide awake
- difficulty waking the patient up
- any problems understanding or speaking
- any loss of balance or problems walking
- any weakness in one or more arms or legs
- any problems with their eyesight
- very painful headache that won’t go away
- any vomiting – getting sick
- any fits (collapsing or passing out suddenly)
- clear fluid coming out of their ear or nose

Things you shouldn't worry about

They may feel some other symptoms over the next few days which should disappear in the next two weeks. These include a mild headache, feeling sick (without vomiting), dizziness, irritability or bad temper, problems concentrating or problems with their memory, tiredness, lack of appetite or problems sleeping. However, if you feel very concerned about any of these symptoms, you should bring the patient to their doctor to talk about them. **If these problems do not go away after two weeks, you must bring the patient to see their doctor.**

Things that will help the patient get better

If the patient follows this advice it should help them get better more quickly and it may help any symptoms they have to go away:

- DO have plenty of rest and avoid stressful situations
- DO NOT take sleeping pills, sedatives or tranquillisers unless they are given by a doctor
- DO NOT play any contact sport (e.g. football) for at least three weeks without talking to their doctor first

Things you should do to make sure the patient is OK

- DO NOT leave the patient alone in the home for the first 48 hours after leaving hospital
- Make sure that there is a nearby telephone and that the patient stays within easy reach of medical help
Telephone number to call at the hospital

Long-term problems

Most patients recover quickly from their accident and suffer no long-term problems. However, some patients only develop problems after a few weeks or months. If you start to feel that things are not quite right for your child (e.g. memory problems, not feeling themselves), then please contact your doctor as soon as possible so that we can check to make sure they are recovering properly.
Appendix 4. Suggested written discharge advice card for carers of adults

We think that it is alright for your friend/relative/client to leave hospital now. We have checked their symptoms and they seem well on the road to recovery. When you get them home it is very unlikely that they will have any further problems. But, if any of the following symptoms do return, we suggest you bring them back to their nearest hospital A&E Department as soon as possible:

- any confusion (not knowing where they are, getting things muddled up)
- any drowsiness (feeling sleepy) that goes on for longer than one hour when they would normally be wide awake
- difficulty waking the patient up
- any problems understanding or speaking
- any loss of balance or problems walking
- any weakness in one or more arms or legs
- any problems with their eyesight
- very painful headache that won’t go away
- any vomiting – getting sick
- any fits (collapsing or passing out suddenly)
- clear fluid coming out of their ear or nose

Things you shouldn’t worry about

They may feel some other symptoms over the next few days which should disappear in the next two weeks. These include a mild headache, feeling sick (without vomiting), dizziness, irritability or bad temper, problems concentrating or problems with their memory, tiredness, lack of appetite or problems sleeping. However, if you feel very concerned about any of these symptoms, you should bring the patient to their doctor to talk about them. If these problems do not go away after two weeks, you must bring the patient to see their doctor. We would also recommend that they seek a doctor’s opinion about their ability to drive a car or motorbike.

Things that will help the patient get better

If the patient follows this advice it should help them get better more quickly and it may help any symptoms they have to go away:

- DO have plenty of rest and avoid stressful situations
- DO NOT take any alcohol or drugs
- DO NOT take sleeping pills, sedatives or tranquilisers unless they are given by a doctor
- DO NOT play any contact sport (e.g. football) for at least three weeks without talking to their doctor first
- DO NOT drive a car, motorbike or bicycle, operate machinery or return to work unless they feel you have completely recovered
Things you should do to make sure the patient is OK

• DO NOT leave the patient alone in the home for the first 48 hours after leaving hospital
• Make sure that there is a nearby telephone and that the patient stays within easy reach of medical help

Telephone number to call at the hospital

Long-term problems

Most patients recover quickly from their accident and suffer no long-term problems. However, some patients only develop problems after a few weeks or months. If you start to feel that things are not quite right for your child or friend/relative/client (e.g., memory problems, not feeling themselves), then please contact your doctor as soon as possible so that we can check to make sure they are recovering properly.
Appendix 5. Data extraction for papers describing rules for diagnosis of c-spine injury

Appendix 6. Data extraction for papers describing rules for head CT selection: adults

Appendix 7. Data extraction for papers describing rules for diagnosis of long term disability

Note: appendices 5, 6 and 7 are available as separate files