HEAD INJURIES IN THE RURAL SETTING: WHAT IS THE ROLE OF THE CANADIAN CT HEAD GUIDELINES?

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ABSTRACT

The Canadian CT head rule is a valuable tool in the clinical assessment of head injuries. It risk stratifies head injured patients, identifying the ones that will require neurological intervention and the ones having clinically important brain injuries (sensitivities 100% and 98.6%, respectively). This standardized approach to head injuries may challenge the rural practitioner without access to CT scan.

The Whistler Health Care Center (WHCC) is a Diagnostic and Treatment Centre seeing approximately 23,000 patients annually, many of them trauma patients with a high acuity level. There is no CT scanner on site. This provides a unique setting to study head injuries: a large number of head-injured patients with limited diagnostic tools, like many other rural facilities in Canada. It was hypothesized that following the Canadian CT Head Guidelines at the Whistler Health Care Center would have increased the number of scans performed.

This study is a retrospective chart review of all patients triaged with head injury, or trauma, to the WHCC in 2004. Canadian CT head guidelines were applied to all charts, and were risk stratified according to the guidelines.

516 charts were reviewed, 305 of which were excluded (5 GCS<13, 1 pregnant, 5 seizures prior to assessment, 56 no amnesia, LOC or disorientation, 38 follow-ups, 174 age < 16 yrs, 22 not seen by MD, 1 acute neurological deficit, 1 unstable vitals, 1

depressed skull fracture, 1 anticoagulant use), and 211 were included. Of the 211 included charts, 51 had CT indicated, and only 4 of these were transferred to a health care facility with CT scan available. A further 9 patients, without meeting the CT criteria were also transferred.

The WHCC has a high number of head injuries annually. When the Canadian CT head guidelines are applied, a greater number of scans are indicated. Some scans, however, in the minor risk group, could have been avoided. When the CT head guidelines are applied to the rural setting without diagnostic CT, patients with high-risk criteria should all be transferred. A prospective study in a similar setting is recommended to determine the management of moderate risk patients.

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INTRODUCTION

Head injury is a very common presentation to the Emergency Department (26). Some conditions, if undiagnosed, can have serious consequences (28, 23). Until recently there was no consensus about the use of imaging in the diagnosis and subsequent management of minor head injury (25, 27, 28)

The Canadian CT head rule is a valuable tool in the clinical assessment of head injuries. It risk stratifies head injured patients, and identifies patients requiring neurological intervention and those having clinically important brain injuries, with sensitivities of 100% and 98.6%, respectively. This standardization in approach to head injuries highlights the challenge to the team physician or rural practitioner, who must make clinical decisions without the benefit of a CT scan.

The Whistler Health Care Center is a Diagnostic and Treatment Facility that has an annual patient census of approximately 23,000, with a high number of trauma patients. The average Canadian Triage Acuity Scale (CTAS) score for head injury patients in Whistler is 2 (emergent). The amount of trauma and sport-related injuries seen in the clinic is out of proportion to what would normally be expected in a rural setting. There is no CT scanner on site. This situation poses a unique opportunity, in that there are a higher number of patients with head injuries at the WHCC, yet there are the limited diagnostic tools like most rural settings in BC.

LITERATURE REVIEW

Many head injuries seen in the emergency department occur during sport (20,22). It is estimated that there are 300, 000 sport related concussions per year in the US (25). Head injury is the most serious type of sport related injury, with a 9% hospital admission rate, compared to 4% from other types of sport related injuries (26). Most head injuries are mild, and the athlete makes full recovery with return to sport (21). Other head injuries, however, have serious consequences, with acute neurological deterioration or acquired brain injury (23,26).

There is controversy about the use of CT scanning in concussion and sport head injury (21, 24, 28). The Vienna group advises against the use of CT unless a structural lesion is expected, there is a progressively worsening headache, or there is a decline in mental status (27). Others have found that no clinical variables are predictive of abnormal CT (29), and that neuroimaging does not account for signs and symptoms following head injury in athletes. (24)

Head injuries are one of the most common types of trauma seen in Emergency Departments in North America (16). Injury is the leading cause of death in the under 45-age group; 50% of which are caused by head trauma (18). The majority of head trauma, however, is minor, with an estimated 1 million emergency visits per year in the United States (7). Mild head injuries are generally defined by a loss of consciousness, amnesia, or disorientation in a patient who is conscious and talking (Glasgow Coma Scale 13-15). (16)

Glasgow Coma Score is a widely used scoring system used to rate level of consciousness. It is made up of three components: eye opening, and eye and motor response (19). The scoring ranges from 3-15, depending on best response according to these criteria: Best Eye Response /4 (1. No eye opening, 2. Eye opening to pain. 3. Eye opening to verbal command. 4. Eyes open spontaneously), Best Verbal Response /5 (1. No verbal response 2. Incomprehensible sounds. 3. Inappropriate words. 4. Confused 5. Orientated) and Best Motor Response /6 (1. No motor response. 2. Extension to pain. 3. Flexion to pain. 4. Withdrawal from pain. 5. Localizing pain. 6. Obeys Commands).

Head injuries have a wide range in outcomes, ranging from asymptomatic to death. The challenge to the practitioner is to identify patients requiring surgery or medical management. The brain can receive different types of injury depending on the direction and force that impacts the head. Primary brain injury occurs immediately upon impact, whereas secondary injury occurs after the event from neurophysiologic and anatomic changes at the cellular level. Types of traumatic brain injury include concussion, skull fractures and intracranial hematomas (2). There are several forms of intracranial hematoma. Bleeding between the skull and dura, typically arising from the middle meningeal artery, causes an epidural hematoma. Subdural hematomas form between the dura and brain, and intracerebral hematomas are contusions to the brain. Diffuse axonal injury (DAI) is the disruption of axonal fibers in the brain cased by shearing forces on the neurons in sudden deceleration. CT scan of DAI is often normal (19).

In centers with CT scanners, this more accurate and useful imaging modality has replaced plain skull radiographs. Computed tomography (CT) is the diagnostic procedure of choice for acute head injury, while magnetic resonance imaging (MRI) has great value for evaluation in the sub-acute and long-term (4). Early scanning of moderate and severe head injuries is common practice (8), yet in mild/ minor head injury, diagnostic approaches vary widely between centers (13,14). Until recently, no guidelines have been able to reliably predict CT abnormalities based on clinical findings (2,5,8,11,14).

The Canadian CT Head Rule was developed to guide the use of CT scanning in adults with minor head injuries. Stiell et al. (17) carried out a prospective cohort study in the emergency departments of ten large Canadian hospitals, to study patients presenting with minor head injuries (17). The goal was to develop a highly sensitive and clinically sensible decision rule, similar to the Ottawa Ankle and Knee Rules.

Some data indicate that low-dose radiation (such as that in CT) may have a significant risk of cancer, especially in young children, therefore, it is important to limit CT radiation (30). This increased risk is presumed to be part of the reason why the under 16-year age group was excluded from this study. Further research in this area is ongoing, with a multi-center study currently underway.

The Canadian CT Head Rule defines populations at high risk for neurological intervention and medium risk for brain injury on CT. The high risk patients are those with a GCS score <15 at 2 hours after injury, suspected open or depressed skull fracture, any sign of basal skull fracture, vomiting >2 episodes or age >65 years (17). The medium risk patients are those with either amnesia before impact >30 minutes, or a dangerous mechanism (pedestrian struck by a motor vehicle, occupant ejected from a motor vehicle, or a fall from >3 feet or 5 stairs). The clinical decision rule identifies patients requiring neurological intervention and those having clinically important brain injuries, with sensitivities of 100% and 98.6%, respectively (17).

In the development of the CT head rule, 24 predictor variables were correlated with outcomes. Logistic regression and recursive partitioning were used to determine the seven criteria used in the Canadian CT Head Rule (17).

Table 1. Canadian CT Head Rule

CT head scan is only required for patients with minor head injury with any one of these findings: **High-risk (for neurologic intervention)** 1. GCS score at 2 hours after injury 2. Suspected open or depressed skull fracture 3. Any sign of basal skull fracture (hemotympanum, "raccoon" eyes, CSF otorrhea/rhinorrhea, Battle's sign) 4. Vomiting $\geq$ 2 episodes 5. Age $\geq$ 65 years **Medium-risk (for brain injury on CT scan)** 6. Amnesia before impact > 30 minutes 7. Dangerous mechanism (pedestrian struck by motor vehicle, occupant ejected from motor vehicle, fall from elevation $\geq$ ft or 5 stairs) "Minor head injury" is defined as witnessed loss of consciousness, definite amnesia, or witnessed disorientation in a patient with a GCS score of 13 to 15.

The Canadian CT Head Rule is a methodologically sound, clinically useful, and highly sensitive prediction rule for detecting clinically important brain injuries. It is more specific than any previous tools, but could increase scan utilization in some centers (1). A larger validation study is currently underway to ensure the results are reproducible. The CT Head Rule is being increasingly used through Europe and North America, with independent evaluations being conducted at various hospitals (1,9,10,13,14).

The Canadian CT Head Rule has recently been compared to the New Orleans Criteria (NOC) for patients with minor head injury and GCS score of 15. The CT Head Rule and the New Orleans Criteria have equivalent high sensitivities for need for neurosurgical intervention and clinically important brain injury, but the head rule has higher specificity for important clinical outcomes than does the NOC, and its use may result in reduced imaging rates (31).

The rural setting poses a challenge in the application of the Canadian CT Head Rule, as management of head injuries in this setting is complicated by several factors (15). Most rural towns do not have CT scanners, and therefore transfer is required to apply the CT Guidelines. Transfer is expensive, and can be dangerous from some remote locations, or in inclement weather. There is also added distress to the patient, who will be transferred from his or her community and support network. Stiell (17) suggests that physicians working in smaller hospitals without CT scanners use the high-risk criteria to select cases requiring a mandatory CT scan; those with medium-risk criteria may be observed or sent for urgent CT (17). This suggestion has not been validated.

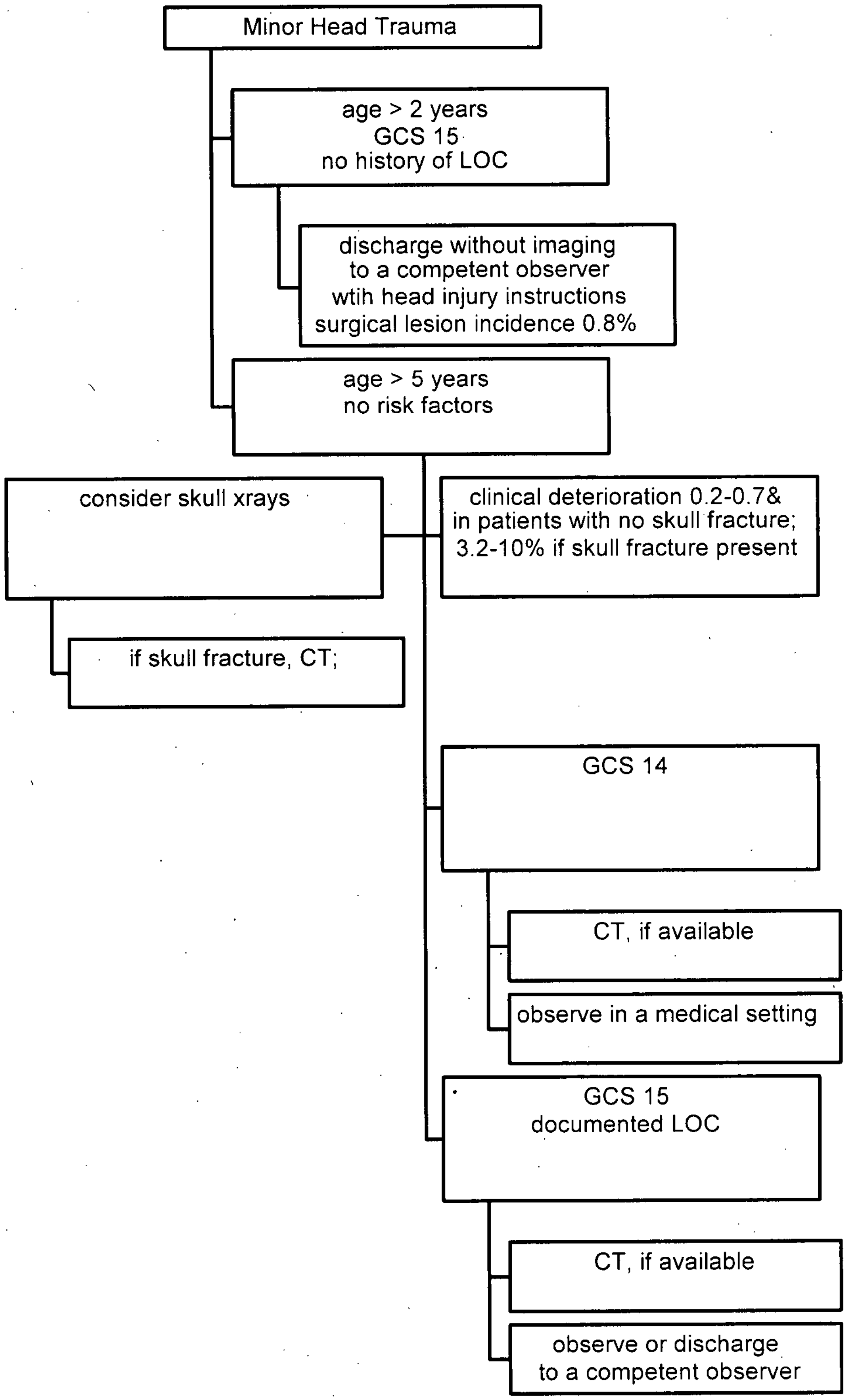
In 2003, a head trauma guideline task force was formed to devise a reasonable approach to head injured patents in the rural and remote regions of Alaska (15). This guide was developed through a literature review and the experiences of 18 rural physicians from around the state. The guidelines are a consensus of the committee, and have not been validated with a clinical trial (15).

The guidelines for the management of minimal head injuries (GCS$\geq$14) in remote and rural Alaska are as follows (see Figure 1). With minimal head injury, patients over two years of age with a GCS of 15 and no history of loss of consciousness can be discharged without imaging to a competent observer. Head injury instructions should be provided.

The incidence of a surgical lesion in this group is reported to approach 0.8%. In mild head trauma in patients over 5 years of age with a GCS of 14, and no risk factors or in patients with a GCS of 15, a documented loss of consciousness and no other risk factors, there are a number of approaches. When a CT scan is available and the GCS is 14 a CT scan is appropriate. Patients with a GCS of 15 can be managed appropriately in several ways including CT scanning, observation under medical supervision or discharge with a competent observer. The decision needs to factor in the patient's social situation as well as local resources. When a CT scan is not available skull x-rays may be helpful in identifying a subset of patients with mild injuries who have a higher risk of deteriorating. Clinical deterioration in patients with a GCS of 14-15 but no skull fracture has been reported in 0.2-0.7% of patients. In patients that do have a fracture present the deterioration rate is 3.2-10% 9. Skull x-rays may facilitate the identification of a subgroup of asymptomatic patients who have a small but real risk of clinical deterioration. If skull x-rays are done and a fracture is noted, the patient should have a CT scan. If there is no fracture identifiable or a skull x-ray is not obtained, the patients need to be observed. Patients with a GCS of 14 without a CT scan or skull x-ray need to be actively observed in a medical setting. Patients with a GCS of 15 can be observed in a medical setting or by a competent observer as an outpatient (15). Patient outcomes and transports have not yet been studied, nor have these guidelines been validated.

Figure 1. Alaska Trauma Head Guidelines

Alaska Trauma Systems Guidelines



The Whistler Diagnostic and Treatment Center provides a unique area to conduct head injury research. It is a rural town, with limited resources, yet deals with 23,000 patient visits annually. The trauma and acuity levels are higher than any other Diagnostic and Treatment Center in British Columbia, and are also higher than in many hospitals (12).

An intake review of the WHCC in 2003 (12) revealed that approximately 500 head injuries were treated. As a CT scanner was not a diagnostic option, patients were transferred, observed or discharged. Outcomes of head injuries diagnosed at this facility have not been formally studied. With the limited resources, and high acuity and volume, Whistler provides an excellent opportunity to examine a large number of head injuries in a rural setting.

OBJECTIVES AND HYPOTHESES

This study is a review of all the disposition of all head injuries seen at the Whistler Health Care Center in 2004. How many were transported to a center with a CT scanner? Of those who were not, who should have been according to the CT Head Guidelines? How many patients were transferred, without meeting CT head guideline criteria? With this project, we were able to examine whether the CT Head guidelines in the rural setting would increase or decrease the number of transfers.

This review could be used to examine the practicality of the CT Head Guidelines in the rural setting. At the WHCC in 2004, were the CT Head Guidelines applied? Would application of the guidelines increase or decrease the number of transfers required? Would it change the patients chosen for transfer? How many of the patients had medium risk criteria? How many had high risk? Results from this study could be applied to the design of a prospective cohort study, and a Rural Canadian CT Head Rule. This rule would benefit physicians with limited CT scan access to guide transfers to medical facilities that can provide CT scanning.

It was hypothesized that retrospectively applying the Canadian CT Head Guidelines to the 2004 head injury patients at the Whistler Health Care Center would have increased the number of scans performed.

METHODS

A retrospective chart review of head injury patients seen at the Whistler Health Care Diagnostic and Treatment Center in 2004 was conducted. The Canadian CT Head Guidelines were applied to all cases. See Appendix 1 for data collection format.

Population

Patients presenting to the Whistler Health Care Center with the triage diagnosis of: head injury, loss of consciousness, trauma, concussion, neck injury or memory loss/ amnesia. Those patients' clinic charts had inclusion and exclusion criteria applied.

Inclusion criteria

- blunt trauma to the head resulting in definite amnesia, witnessed loss of consciousness or disorientation;
- initial ED Glasgow Coma Score of >13; and
- injury within the past 24 hours

Exclusion criteria

- age <16 years
- no history of trauma as the primary event
- obvious penetrating skull injury or depressed fracture
- acute focal neurological deficit
- acute trauma with unstable vital signs

- seizure prior to ED assessment
- bleeding disorder, or anticoagulant use
- a return to the ED for reassessment of the same head injury
- pregnancy

Patients included in the study were stratified into medium and high-risk groups, as defined by the CT Head guidelines. Disposition of these patients was recorded.

The investigation process reviewed charts selected for the study, patient demographics, included and excluded charts, mechanism of injury, patients with medium or high risk criteria, patients who met criteria who were then transferred, and other patients who were transferred.

Statistics

Calculation of sample population estimates in each group was performed, with a 95% confidence interval. Plus Four Confidence Intervals were used in populations close to 1 or 0. Two reviewers evaluated ten percent of charts, and K coefficient was used to correlate recorder agreement (proportion of potential agreement beyond chance). This calculation was done to determine if this study would be repeatable by another reviewer. The WHCC study population demographics were compared with the Stiell's original study (17), using a T-test to compare means, and X^2 to compare proportions. A total of 516 charts, from 554 patient encounters (38 follow-ups), were reviewed from the 2004 year.

Limitations

There are several limitations to the design of this study.

In conducting a record review, it is expected that some cases will be missed due to data coding inconsistencies (for case finding), as well as inability to locate some medical records. Other head injured patients that did not seek medical attention, would also have been missed. For the cases that are reviewed, patient consent had not been obtained for follow-up; therefore outcome is limited as to whether or not a patient is transferred. In reviewing the chart, the recorder may have a different impression of the patient than the attending physician. Finally, this data may not be detailed enough to apply the Canadian CT Head rule.

Medical record review studies are retrospective data set studies using patient data where the research question is posed after the data has been collected, and therefore inherently flawed (6,19). In retrospective studies, a causal relationship cannot be determined. There are no universally accepted standards for conducting or reporting retrospective data, however, work is currently being done in this area (3).

This study is a retrospective chart review. The privacy act and UBC ethics do not allow for patient follow-up unless consent has been obtained prior to patient contact. Since the charts and patients reviewed in this study did not sign prior consent, follow-up was not an approved component of the ethics application.

RESULTS

Charts reviewed

A list of all 2004 visits to the WHCC, with the admitting category of trauma or neurological was produced. This list was reviewed to identify all cases with the diagnosis of head injury, concussions, trauma, or another synonym.

Five hundred and sixteen charts (554 patient encounters) were identified. All charts were pulled from filing by reception staff at the WHCC for subsequent review. Thirty-eight of the charts were follow-ups; therefore 554 patient encounters yielded 516 patient charts (see Table 2).

Exclusion criteria (as defined above) were applied to all charts.

There were 174 patients who were under the age of 16, all of whom had a history of trauma, one with a depressed skull fracture, one with an acute neurological deficit, one with unstable vital signs, 5 with a seizure prior to assessment, one on anticoagulants, and one pregnant.

Table 2. Cases Having Exclusion Criteria

Reason for exclusion	Cases	Transfers
Pregnant	1	0
Seizure prior to assessment	5	1 LGH
Return to clinic	(38)	0
Age<16yrs	174	0
Not seen by MD	22	0
Acute neurological deficit	1	1 LGH
Acute trauma/unstable vitals	1	0
Obvious penetrating skull injury/depressed fracture	1	1 LGH
Bleeding disorder or anticoagulant use	1	0
Total	**206**	**3**

Upon completion of application of exclusion criteria, 310 charts remained. Next, inclusion criteria were applied.

Inclusion criteria:

1) blunt trauma to the head resulting in definite amnesia, witnessed loss of consciousness or disorientation;
2) initial ED Glasgow Coma Score of >13; and
3) injury within the past 24 hours

There were 99 charts that did not meet the inclusion criteria. Fifty-six patients did not have a history of amnesia, loss of consciousness, or disorientation; 5 patients had a Glasgow Coma Score of less than 13, and 38 had not had a head injury within the last 24 hours (see Table 3).

Table 3. Cases Not Meeting Inclusion Criteria

Reason	Number	Transfers
No amnesia, LOC or disorientation	56	
Patient with GCS<13	5	1 VGH, 2 LGH
No head injury within 24 hrs	38	
Total	**99**	**3**

After application of inclusion and exclusion criteria, 211 (40.8%) charts remained for review. (See tables 4 and 5)

Table 4. Charts Not Meeting Criteria

	Not meeting inclusion criteria	Having an exclusion criteria	**Total**
Number of Cases	99	206	**305**

Table 5. Included Charts

	Excluded	Included	**Total**
Number of cases	305	211	**516**

The Canadian CT Head Guidelines were then applied for medium and high-risk criteria.

High-risk (for neurologic intervention):

1) GCS score <15 at 2 hours after injury
2) Suspected open or depressed skull fracture
3) Any sign of basal skull fracture
    a. Hemotympanum
    b. "Raccoon" eyes
    c. CSF otorrhea/rhinorrhea
    d. Battle's sign
4) Vomiting ≥2 episodes
5) Age ≥65 years

Medium-risk (for brain injury on CT scan):

6) Amnesia before impact >30 minutes
7) Dangerous mechanism
    a. Pedestrian struck by a motor vehicle

b. Occupant ejected from a motor vehicle

c. Fall from elevation ≥ 3 feet or 5 stairs

Of the 211 charts without exclusion criteria, and meeting inclusion criteria, there were 9 patients with high risk, and 42 with medium risk. Of the 9 patients meeting high risk criteria for neurosurgical intervention, there were 2 patients with a GCS<15 at 2 hours, 3 with greater than 2 episodes of vomiting, and 4 over the age of 65. Of the 42 patients meeting medium risk for brain injury on CT scan, 10 had amnesia greater than 30 minutes prior to the incident and 32 had a dangerous mechanism. Of the 32, 30 fell from a height greater than 3 feet, and 2 were ejected from a motor vehicle.

The patients meeting medium or high-risk criteria have a CT indicated, according to the Canadian CT Head Rule. Of the 51 who had a CT indicated in this review, 4 were transferred to a center with a CT scanner. Two of these patients had high-risk criteria, and 2 of them had medium risk criteria. Of the remaining 160, 9 were transferred to a center with a CT scanner, and 2 were sent to a community hospital for observation (see tables 6 and 7, and figure 2).

Table 6. Result Summary

516 charts		
305 excluded	206 with exclusion criteria	
	99 without inclusion criteria	
211 included	42 with medium risk*	40 discharged home
		2 sent to a center with CT
	9 with high risk*	7 discharged home
		2 sent to a center with CT
	160 no CT indicated	149 discharged home
		2 sent to a center for observation
		9 sent to a center with CT

*medium and high-risk patients have CT indicated

Table 7. Disposition Summary

Total Patients	Excluded	Included	Transferred
516	305	211	Total transferred: 13 4 with CT indicated 9 without CT indicated

Figure 2. Patient Disposition

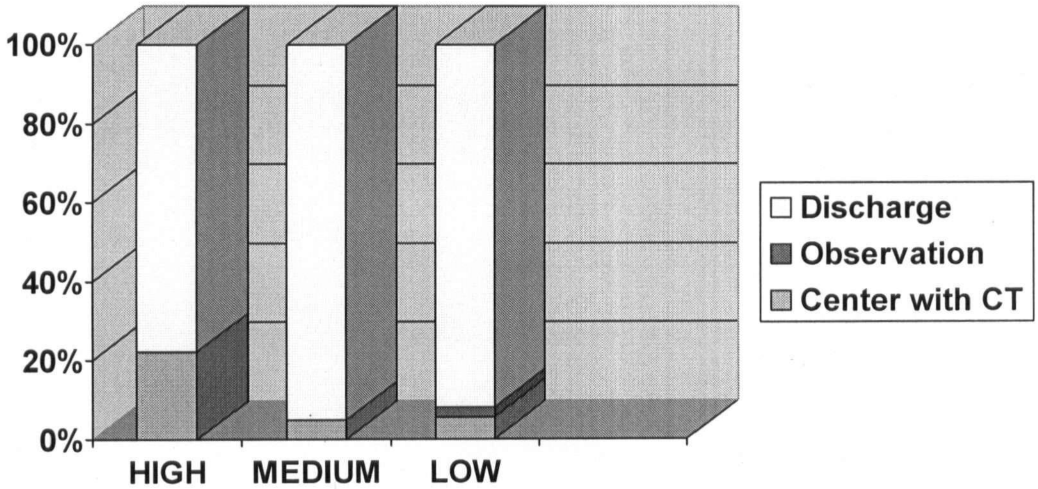


Table 8. Acuity Levels

Risk Level	Lancet	WHCC	Difference (p<0.01)
High	1%	4%	100% confidence
Medium	8%	20%	100% confidence

Table 9. Injury from Sport

	Lancet	WHCC	Difference (p<0.01)
Percentage of Injury from Sport	16%	78%	100 % confidence

Patient Demographics and Recorder Agreement

The mean patient age was 27.5 years (11), the age range was 16-71 years (note 174 cases under the age of 16 excluded), and the proportion of male patients was 73%. In the original study, the mean age was 38.7 years (18), the age range was 16-99, and 69% of the patients were men. With a T value of 14.16 (0.79), the ages between the 2 study groups were statistically significant. X^2 was used to compare proportions of male gender between the two groups. With a standard error of 2 (95% confidence interval), there was no statistically significant difference between genders in the two studies. As demonstrated in Tables 8 and 9, the WHCC had a statistically significant higher acuity level (100% C.I., $p<0.01$), as well as a greater number of injuries from sport (100% C.I., $p<0.01$). Two different recorders reviewed ten percent of charts in order to correlate the proportion of potential agreement beyond chance. This correlation was found to be $K=0.89$.

DISCUSSION

The application of the Canadian CT Head Guidelines in the setting without a CT scanner poses a challenge to the practitioner in that arranging a CT scan and transporting the patient to the appropriate facility can be complicated. In the rural setting, patients are often observed and discharged, whereas in a center with a scanner, a CT head is frequently performed. From the rural setting, the patient must leave his or her community and face the risks and costs of travel in order to carry out the prescribed Canadian guidelines, which have been developed in a tertiary-care setting. The Canadian CT Head Guidelines were designed to decrease the number of scans being done, reduce the number of clinically important missed cases, and standardize care across the country (17). It was hypothesized that in the rural setting, application of the guidelines would increase the number of recommended scans.

The Canadian CT Head rules were published in 2001, and most of the WHCC physicians were aware of these. The guidelines were not posted in the ED, nor determined to be the standard of care in that setting. Use of the guidelines varied with individual physicians. With the exception of one, all Whistler ER doctors are solely in Emergency Medicine Practice, half of whom hold a CCFP-EM certification, and the others whom have enough experience to be eligible to challenge the EM certification. When compared to other rural settings it is likely the Whistler physicians have more emergency medicine training and experience.

The goal of this study was to see if the guidelines, when retrospectively applied to a set of charts in the rural setting, changed the disposition of patients with minor head injury. This study was conducted on head injury charts at the Whistler Health Care Center because of an unusually large number of high acuity cases arising in a rural setting. A certificate of ethics approval was obtained from the University of British Columbia Clinical Research Ethics Board prior to collecting any patient information (Appendix 2).

Of the 516 charts that were reviewed, 211 remained after application of inclusion and exclusion criteria. Of the 9 patients with high-risk criteria, 2 were sent to a center with a CT scanner, and 7 were discharged home. Of the 42 patients with medium risk criteria, 2 were referred to a center with a scanner, and 40 were sent home. In the 160 patients with minor head injury, which did not meet the "CT indicated" criteria, 9 were sent to a center with a scanner, 2 were sent for observation, and 149 were discharged home. Fifty-one patients would have been sent for a scan if the guidelines had been followed, whereas only 13 were referred. There would have been 9 fewer scans in the "not indicated" group, and 47 more in the "indicated" group. It is not clear why some patients with low risk were referred a center with a scanner. These results exemplify the need for standardization of head injury management in that some clinically important cases may have been missed, and some transfers for CT scans could have been avoided.

Of note, there were 174 children under the age of sixteen identified in this study. Although the Canadian CT Head Guidelines do not make recommendations for this age group, another study is currently underway. The 'CATCH' study has been designed to form the Canadian Pediatric CT Head Rule. Phase one of this study is underway, with 3014 head injured patients reviewed so far. Approval for the second phase of this study is pending. Current recommendations for the Pediatric CT Head Rule are that CT is only required for minor head injury in patients with any medium or high-risk findings. High risk findings in the pediatric group are an initial GCS score <15, suspected skull penetration or depressed skull fracture, lethargy on exam and irritability on exam. Medium risk criteria are any sign of a basal skull fracture, a large, boggy scalp hematoma, a fall from a height of greater or equal to 3 feet or greater or equal to 5 stairs and a decreased level of consciousness after assessment (32). The NEXUS II study is a multi-center, prospective, observational study of all blunt head trauma victims who had a CT as part of their ED evaluation. Clinically important intracranial injuries were identified by seven NEXUS II risk criteria: (1) evidence of significant skull fracture; (2) altered level of alertness; (3) neurologic deficit; (4) persistent vomiting; (5) presence of scalp hematoma; (6) abnormal behavior; and (7) coagulopathy (43). A prospective cohort study in the rural setting, which includes ages under sixteen, should also be developed.

Exclusion criteria in the CT head rule could limit the exclusions to a younger age group as current evidence suggests that the increased concern and risk for the development of solid tumors is predominantly in younger children (43). In a one year old, the radiation exposure is a magnitude higher than adults, and that pediatric CT would result in significantly increased lifetime radiation risk over adult CT, because of increased dose per milliampere-second, and increased lifetime risk per unit dose (44). For this reason, there have been recommendations to reduce the tube current (radiation) based on patient weight (45). The National Research Council's Committee on the Biological Effects of Ionizing Radiation has estimated that children less than 10 years of age are several times more sensitive to radiation that middle-aged adults (46). Because children have more rapidly dividing cells than adults and have longer life expectancy, the odds that children will develop cancers from x-ray radiation may be significantly higher than in adults (47). Significant debate continues about the age where radiation dose equals that in adults. This is likely why the CT Head rule excludes the entire pediatric group, for which a separate set of guidelines are being created.

Had the pediatric age group been studied at WHCC, the number of subjects in this review would have been close to 400, thus increasing its power and utility.

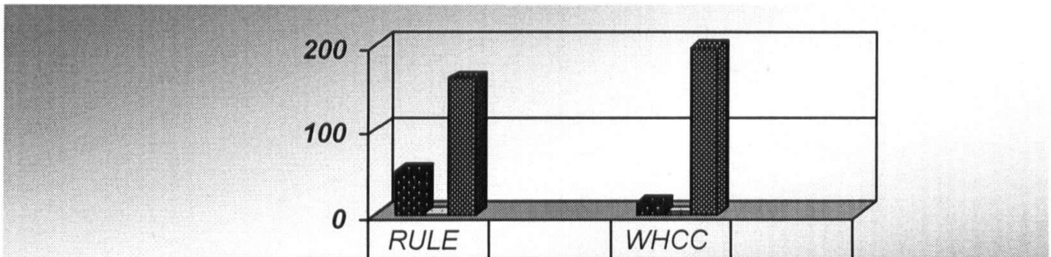
In contrast to the current practice in the pediatric group, a study completed this fall examined a different method of managing pediatric head injury in the United Kingdom. In the U.K., approximately 500,000 children present to the emergency department with a head injury, and about 50,000 are admitted. The death rate is 5.3 per 100,000 children. This study compares management of a minor head injury with either immediate computed tomography for triage inpatient admission. Early discharge after immediate computed tomography had the same recovery at three months, no later complications, and equivalent patient satisfaction. It was also less costly than inpatient observation (35). This study was done in a center with a CT on site.

Overall, application of the CT Head guidelines to WHCC 2004 head injury charts would have increased the total number of patients transferred for a scan by four times, with a thirteen fold increase in the "CT indicated" group. It would, however, have decreased the number of scans performed in the "not-indicated" group by nine (see Table 5).

In the literature, there are no clear guidelines as to the proper disposition of head injured patients in the rural setting. In the Canadian CT Head Rule for patients with minor head injury Stiell et al. (17) suggest that physicians working in smaller hospitals without CT scanners use the high risk criteria to select cases requiring a mandatory CT scan and those with medium-risk criteria be observed or sent for urgent CT. This suggestion is an expert opinion, and was not based on clinical outcome data.

If Stiell's rural suggestion (17) was followed, 9 (4%) of the 211 reviewed charts would have required a mandatory CT scan, and 42 (20%) would have been observed or sent for an urgent CT. This would increase the number of CT referrals from the WHCC, whether just the high, or both the high and medium risk patients were sent for CT. See Figure 3 for comparison of the WHCC outcomes and the hypothetical outcomes had the rule had been applied.

Figure 3. Comparison of Outcomes



	RULE		WHCC	
CT	51		13	
Observation	0		2	
Discharge	160		196	

The following details the patients selected for transfer for CT scan. The two in the high-risk group continued to have a GCS score of <15 at 2 hours after injury. Of the 2 transferred from the medium risk group, one had amnesia before impact >30 minutes, and the other was a multi-trauma. The transfer in the 'no CT indicated' group included 2 multi-traumas. The rationale for the referral of the other 7 in this group was not apparent from the medical record.

As Stiell's Lancet guidelines are currently the gold standard for head CT clinical decision-making in Canada, the application of his suggestion for the rural setting would change the practice of the physicians at the Whistler Health Care Center. Overall, more patients would be referred, however, there would be a decrease in the referral of the 'no CT indicated' cohort.

Transferring patients from Whistler to Vancouver for CT scan may not improve patient care. There is an inherent risk with Emergency transport, particularly in poor weather and road conditions. Transport has risk, as well as significant expense, with a cost of $3120 by air, or $500 by ambulance (36). At the end of the investigations, patients are left over 100 km from home, with no return transport. In addition to the cost and risk of transport, the CT scan itself is not without risk. A CT Head has approximately the same amount of radiation as 150 chest X-Rays (29).

The cost of a head CT scan ranges from $330 to $460, whereas hospital observation costs range from $700 to $990 (42). The price of a CT scanner is approximately $970,000, with $400,000 per year in operating costs (42). The current estimated cost of rehabilitation from a significant brain injury is 4 million dollars per patient, and one estimate of the "cost of death" is 3.1 million dollars (42). The cost of scanning, as well as the cost of missing a case must both be considered when performing a future cost-benefit analysis. When comparing cost of CT and cost of observation overnight, a CT scan is cheaper. WHCC patients (with the exception of two) were sent home, so the overnight admission was negligible. WHCC likely saved money with its management of 2004 head injuries.

The Canadian CT Head rule was designed to increase the sensitivity and specificity of detection of important minor head injuries. It was also designed with the intentions of decreasing the number of scans performed by 25-50% (17). A study of the impact of the guidelines on British management of ED head injuries found that the Canadian CT Head

Rule would result in an increase in the number of scans requested for minor head injuries, and an increase in cost (33).

Reviewing one year's charts from Whistler, there would have been an overall increase of 400 percent in CT scans in minor head injury patients, had the CT Head Guidelines been applied. Utilization of the rule, however, could have decreased scans in the low risk group. Overall, the Canadian CT Head Guidelines may be too inclusive for the rural population. Preliminary recommendations, requiring validation, are as follows: do not transfer the low risk group for CT; always transfer the high risk group for CT; use clinical judgment in the medium risk group with the options of transfer for CT, observation or discharge to an appropriate care giver.

There was a significant difference between the WHCC population, and the population in Stiell's article. In Whistler, 78% of the head injuries were from sport, as compared to 16% (derived from the combination of the bike, sport and contact sport categories). The proportions of these groups were significantly different, with a 100% confidence level ($p<0.01$). Whistler patients also had a higher acuity level. The WHCC population had 4% in the high-risk group, and 20% in the medium risk group, compared to the Lancet article with 1% and 8%, respectively. The proportions in both the high and medium risk groups in the WHCC study, as compared to the Lancet article (17) were both statistically significantly different, with 100% confidence ($p<0.01$).

Of the 211 patients meeting inclusion and exclusion criteria, 45 were skiing, 93 were snowboarding, 4 were skateboarding and 48 were cycling. Of the other 21, 9 were involved in altercations, 7 had falls while intoxicated, and 5 had other falls.

Mechanism of injury in sport varies depending on the nature of the sport, the use of protective equipment, and the expertise level of the participant. The WHCC study had a significantly higher proportion of sport related injury when compared to the original article, as well as a higher acuity level. As most of these sport related injuries occurred on the ski hill or in the mountain bike park, the mechanisms of injury are likely quite different from those sport injuries that were included in the original article. For this reason, a study that would better represent the rural population would have to include other communities. Alternatively, if there were to be a rule created purely with the WHCC data, it would be specifically for a similar environment.

A third phase of Stiell's study is underway. Phase I of the study successfully derived the rule, and phase II confirmed the accuracy and safety of the rule. Phase III is designed to examine the actual change of behavior of physician, and is designed to study the effectiveness and safety of an active strategy to implement the Canadian CT Head Rule into practice. The objectives are to: 1) Determine clinical impact by comparing the intervention and control sites for: a) CT Head ordering rates, b) Missed neurological intervention cases, c) Missed brain injuries, d) Number of deaths, d) Length of stay in ED, and e) Patient satisfaction; 2) Determine sustainability of the impact; 3) Evaluate performance of the Canadian CT Head Rule (B). A similar study in the rural setting would be of great value in comparing risk and benefit with the given transport risks and costs.

The Canadian CT rules are now more publicly accepted and studied as compared to 2004. Utilization of the rule would have probably increased since that time. In order to evaluate the current practice of the WHCC group, a utilization study similar to Stiell's current project could be done at Whistler (34).

A study of the effect of a rural CT scanner on local health care in Walkerton, Ontario was published last month (37). This community of approximately 5000 people is 160 km away from a tertiary care setting, and 70 km from a secondary center. A pilot project was held to study the effect a rural CT would have on local heath care. It was found that CT improved local health care in that physicians were able to reach diagnoses more quickly, initiate treatment sooner, and make better-directed referrals to specialists. Patient satisfaction was also improved—rural patients want to be cared for in a rural environment. CT scanning rates in the rural setting grew closer to, but did not exceed the rates of scanning in the urban setting (37). An independent review of the costs and revenue found that the scanner did not affect the hospital's resources negatively (37). This pilot study was concluded early, and a CT scanner fully authorized by the Ministry because of significant improvement in the area's health care (37).

Having a scanner in Whistler would improve patient care with early diagnosis, treatments, and timely appropriate referrals. It would eliminate the risk and cost of transport in those without significant brain injury on CT, and improve patient satisfaction of their care. A cost analysis would be required to determine whether a scanner in Whistler would reduce overall health care costs.

Further study needs to be done to better understand the challenges and limitations of diagnostic imaging in the rural setting, particularly after traumatic brain injury. In order to design a clinical decision-making rule for the setting without a CT scanner, a prospective study in a similar setting should be performed. Based on evidence from Stiell et al. (17), it is reasonable to send all high-risk patients for CT. The moderate risk group, however, would benefit from a further assessment of guidelines, examining clinical outcomes, as well as cost and risk of travel.

In such a prospective cohort study, patient consent would be obtained for inclusion in the study, consent for follow-up of symptoms, medical charts, CT results, interventions and outcomes. The future study would thus allow for detailed follow-up. Data would be recorded from the initial patient presentation, history and physical examination. As in the Stiell study (17), questions from history would be age, gender, arrival by ambulance, witnessed loss of consciousness (LOC), duration of LOC, amnesia, headache, suspected chronic alcohol use, repeated vomiting, serum ethanol level, mechanism of injury/ sport, use of helmet, use of seatbelt. Data obtained from physical exam would include initial GCS, deterioration in GCS, pupils equal and reactive, lateralizing motor weakness, possible open skull fracture, sign of basal skull fracture, intoxication (drug or alcohol), object recall, seizure in emergency department. Patient management and outcomes would then be recorded. These outcomes would be whether imaging was done (head CT or skull radiographs), and follow-up of cases for sequelae. Findings on history and physical would be correlated by stepwise logistic regression analysis to predict clinically important brain injury (16), as was done in the Stiell article to create the Canadian CT Head Rule (17). Other outcomes from the rural setting would be distance, method and cost of transport, negative outcomes during transport, and costs of medical care in the receiving facility.

In the design of the Lancet study, the priori sample size was estimated to be 2500 patients based upon the desired precision of 100% sensitivity for clinically important brain injury with a 95% confidence interval (17). Theoretically, a similar number would be required in a rural setting study. Because of the higher incidence of the high and medium risk groups in the Whistler setting, a smaller 'N' would be required, calculated to be 813, based on incidence proportions relative to Stiell's study (17).

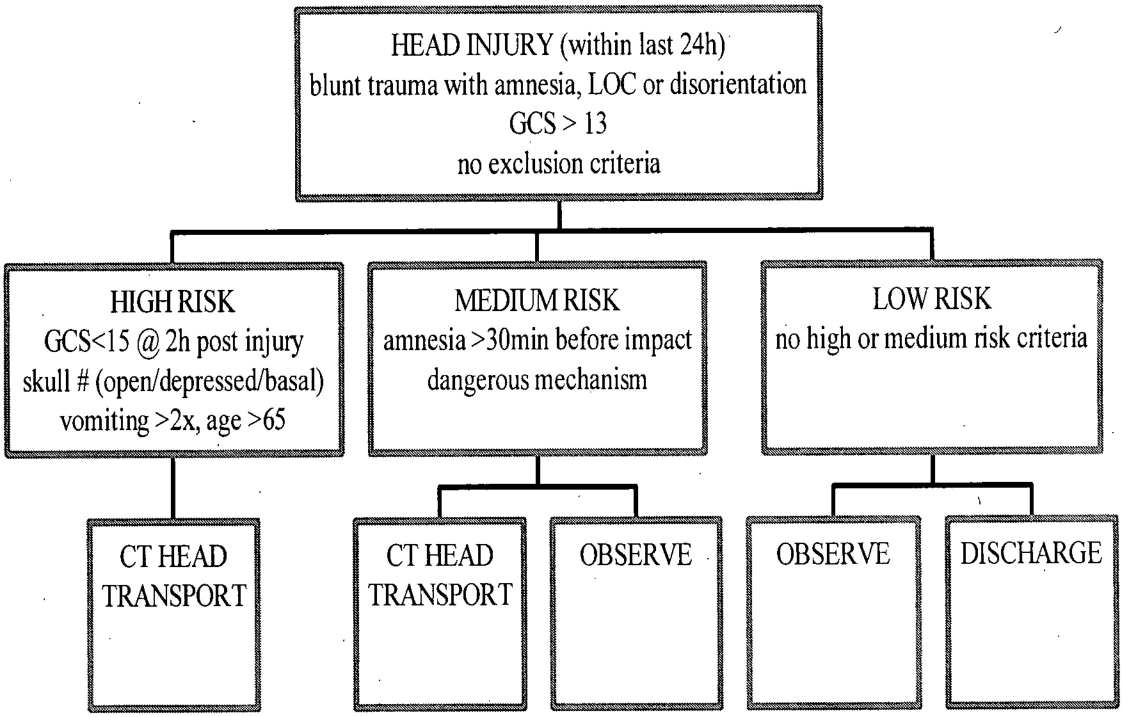
The goal of this study would be to create a template for a multi-center study, from which a rural CT head rule could be developed, and published for the use of all rural practitioners in Canada. The goal would be to create an equivalent to the "Ottawa Ankle Rules" for CT Head in the rural setting.

The Ottawa ankle rules have been extensively studied, and have been shown to decrease ankle radiography by emergency physicians from 82.1% to 61.6%; ($P < 0.001$); and by family physicians from 84.3% to 60.1%; ($P < 0.001$) (38). When the Ottawa ankle rules were implemented in a study setting, there was a decrease in use of ankle radiography, waiting times, and costs without patient dissatisfaction or missed fractures (40). Despite the cost of missed fractures (including litigation costs), the Ottawa ankle rules would result in significant savings of health care dollars (39). Although this clinical guideline is widely accepted, this does not always cause a change in physician behavior. Despite physician knowledge of the Ottawa Ankle Rules, in a review of actual clinical practice, with there was no reduction in ankle radiography (41).

Recommendations

Until more conclusive evidence exists, it is recommended that all patients with minor head injury meeting the high-risk criteria be referred for mandatory CT. Those patients with medium risk criteria, should be considered for CT, or held for observation. Finally, it is recommended that all patients with any form of head injury be discharged to a reliable caregiver, and have early follow-up arranged for reassessment. The proposed 'Rural Canadian CT Head Guidelines' are illustrated below in Figure 4.

Figure 4. Rural Canadian CT Head Guidelines



The implications of this research have already reached the global and local community. Results were published in the Canadian Journal of Emergency Medicine in May 2006, and presented at the International Congress of Emergency Medicine in June 2006. On November 1, 2006, the Whistler Health Care Foundation announced the start of a campaign to raise two million dollars to purchase and install a CT scanner at the WHCC.

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APPENDIX 1: DATA COLLECTION SHEET

Chart number____________
Date of admission _____________

☐ **any exclusion criteria? If so, stop now.**

-age <16 years
-no history of trauma as the primary event
-obvious penetrating skull injury or depressed fracture
-acute focal neurological deficit
-acute trauma with unstable vital signs
-seizure prior to ED assessment
-bleeding disorder, or anticoagulant use
-a return to the ED for reassessment of the same head injury
-pregnancy

☐ **inclusion criteria met? If not, stop now.**

-blunt trauma to the head resulting in definite amnesia, witnessed loss of consciousness or disorientation;
-initial ED Glasgow Coma Score of >13; and
-injury within the past 24 hours

☐ **GCS score <15 at 2 hours after injury,**
☐ **suspected open or depressed skull fracture,**
☐ **any sign of basal skull fracture (battles, otorrhea, rhinorrhea, raccoon),**
☐ **vomiting >2 episodes or**
☐ **age >65 years**

☐ **amnesia before impact >30 minutes, or a**
☐ **dangerous mechanism**
  ☐ **pedestrian struck by a motor vehicle,**
  ☐ **occupant ejected from a motor vehicle, or a**
  ☐ **fall from >3 feet or 5 stairs**

Transferred?
☐ **no**
  ☐ **time in ER: admission_________ discharge_______**
☐ **yes**
  ☐ **LGH** ☐ **VGH** ☐ **St Pauls** ☐ **Squamish** ☐ **other __________**