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Have changes in computerised tomography guidance positively impacted detection of cervical spine injury in children? A review of the Trauma Audit and Research Network data

Catherine Nunn[1], Samantha Negus[2], Tomas Lawrence[3], Fiona Lecky[4] and Damian Roland[1,5]

Abstract

Background: Clinically significant damage to the cervical spine in children is uncommon, but missing this can be life-changing for patients. The balance between rarity and severity leads to inconsistent scanning, with both resource and radiation implications. In 2014, the United Kingdom's National Institute for Health and Care Excellence updated their computerised tomography neck imaging guidance in children. The aim of this study was to assess if the change in guidance had resulted in a change in diagnosis or imaging rates.

Methods: A retrospective review of the national Trauma Audit and Research Network's data for computerised tomography spine imaging in children in 2012–2013 was compared to the same data sample collected in 2015–2016.

Results: The percentage of children presenting with neck trauma who were imaged reduced from 15.5 to 14.1% with an increase in confirmed cervical spine injury from 1.6 to 2.3% between the two time periods. The specificity of computerised tomography scanning increased from 10 to 16.4%. There was variation in scan rates, with major trauma centres scanning a greater percentage of children of all ages and with all injury scores, than trauma units.

Discussion: This study suggests national guidance can impact clinical care in a relatively short timeframe. Variation in how guidance is applied, with major trauma centres scanning proportionately more children with a lower yield, could be because scanning is more readily available, or because trauma protocols encourage more scans. Twenty per cent of injuries were not found on the initial computerised tomography, in keeping with previously reported data, because the injuries were ligamentous or cord contusion. This suggests a role for early magnetic resonance imaging in children with suspected spinal injury.

Keywords

Computerised tomography, spine, children, guidance

Introduction

Significant injury to the cervical spine in children is uncommon in the UK, being present in 1.6–2.3% of seriously injured children.[1] However, it remains a concern for many paediatric trauma patients due to the potentially severe consequences of missed unstable injuries. Deciding when radiological evidence is required to clear the c-spine, accessing appropriate imaging and

[1]Paediatric Emergency Medicine Leicester Academic (PEMLA) Group, Children's Emergency Department, Leicester Royal Infirmary, Leicester, UK
[2]Surrey and Sussex Healthcare NHS Trust, East Surrey Hospital, Redhill, UK
[3]TARN, University of Manchester, Manchester, UK
[4]Centre for Urgent and Emergency Care Research (CURE), Health Services Research Section, School of Health and Related Research, University of Sheffield, Sheffield, UK
[5]SAPPHIRE Group, Health Sciences, Leicester University, Leicester, UK

Corresponding author:
Catherine Nunn, Paediatric Emergency Medicine Leicester Academic (PEMLA) Group, Children's Emergency Department, Leicester Royal Infirmary, Leicester LE1 5WW, UK.
Email: cnunn@doctors.net.uk

attribution of findings are all challenges. Plain X-rays can be difficult to perform and interpret, and even good quality X-rays miss some injuries.[2,3] Computerised tomography (CT) of the neck is quick and easily performed in conjunction with a head CT, and is widely available, but also has a relatively high radiation dosage which has been shown to significantly increase the likelihood of tumours in children.[4–6] MRI is accurate but relatively slow, requires specialist interpretation, and is logistically challenging, needing sedation or anaesthesia. In the acute setting having the patient placed centrally within the scanner may be inappropriate or unsafe. Keeping an awake child immobilised is also difficult, requiring a degree of skill from staff, and if unnecessary, is unkind as well as a waste of time and resources.

In the United Kingdom, NICE (currently the National Institute of Health and Care Excellence) have produced guidance aiming to simplify the decision making process and reduce potential radiation dosage to children. In 2014, the guidance in relation to the use of CT neck scans in trauma was updated for children with head injury.[7]

The indications for scanning all children within 1 h were simplified to:

- GCS < 13 on initial assessment
- Intubated
- A definitive diagnosis of cervical spine injury (CSI) is urgently required
- Other areas are being scanned for head injury or multi-region trauma
- Focal neurological signs
- Paraesthesia in the upper or lower limbs
- Strong clinical suspicion of injury despite normal X-rays
- Inadequate X-rays
- X-ray demonstrates a significant abnormality

These changes have not been significantly altered in subsequent NICE guidance relating to neck injury,[7] *but a CT neck is not automatically indicated with a CT head*. We sought to evaluate the impact the new guidance has had.

Methods

The Trauma Audit and Research Network (TARN) routinely collects data about paediatric major trauma patients – including those with CSI and records the type and timing of imaging they receive. TARN collects data from both major trauma centres (MTCs) and trauma units (TUs). Patients are included if they are under 16, present to a MTC or a TU in England and meet the TARN inclusion criteria of requiring either critical care, an inter-hospital transfer for ongoing acute care, a stay of more than three days, or die after arrival.

Data were extracted from the TARN database on all patients aged under 16 presenting to trauma receiving hospitals in England in 2012 and 2013 when the original guidelines were in place and during 2014–2015 after the new guideline was published. We determined whether or not children had a cervical spine CT, their age at presentation, mechanism of injury, and highest level of any CSI. The reports of their CT scan and subsequent MRI scans were also analysed. We excluded 16 transferred patients from the final analysis, nine of whom had neck imaging and seven who had fractures, as it was impossible to say on which scan the fractures were identified.

TARN has ethical approval from the Health Research Authority (PIAG section251) for research on the anonymised data that it holds.

Results

Between 2012 and 2013, 4694 injured children were included in the TARN database, 83 (1.8%) of which had a CSI of any kind; overall paediatric submissions increased by 7% to 5011 in 2015–2016 with 127 (2.5%) children sustaining a CSI (Table 1). Total CT scan rates decreased from 643 to 609 (13.7 to 12.2%), but this was not statistically significant.

Teenagers were most likely to have sustained a CSI, with 39 (3.1% of teenage major trauma cohort) injuries in the first time period and 53 (3.9% of teenagers) in the second; all other age groups had 20 or less total injuries in both cohorts, <2.5% of each age group. Rates of CSI in those children initially imaged with CT *increased* from 10 to 16.4%, and although the trend was reflected across almost all age groups this was not evenly spread (Figure 1). The percentage of CSI in 2–3 year olds showed the biggest increase with CSI rates increasing from 2.9 to 23.8%.

In both groups the most likely mechanism of injury to cause CSI was road traffic collision (RTC), resulting in over 50% of all injuries during both time periods (Figure 2); falls were the next most common, with few injuries being caused by blows or ‘other’ mechanisms (including horses), and only one caused by stabbing.

Not all CSI was identified on the initial CT, with over 20% being falsely negative in both series, with injury identified on subsequent MRI. For both series, reports were missing in a substantial number of patients (34% in the first group and 31% in the second). Both time periods showed a higher proportion of children being scanned at MTCs (Table 2), with TUs appearing to be more selective; however, both MTCs and TUs did show a reduction in the percentage of scans performed

Table 1. Age and level of vertebral injury.

Level of vertebral injury	Age of patient 0–1	1–2	2–3	3–4	4–8	8–12	12–16	Total
1	1	1		2	4	10	7	25
2	3	4		3	9	3	16	38
3					1	2	6	9
4		1		1	1	6	12	21
5			2		1	2	16	21
6	3					2	7	12
7	4			3	4	5	11	27
Unknown	10	5	5	6	8	6	17	57
Total	21	11	7	15	28	36	92	210

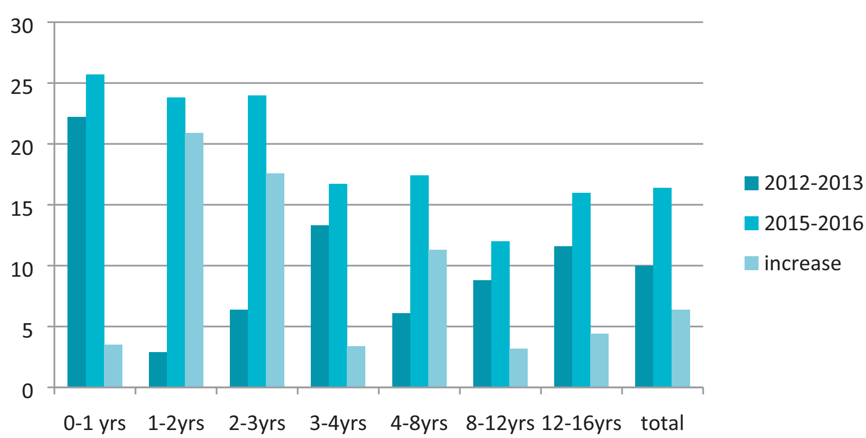

Figure 1. Percentage of injured children found to have CSI post CT scan by age and time cohort.

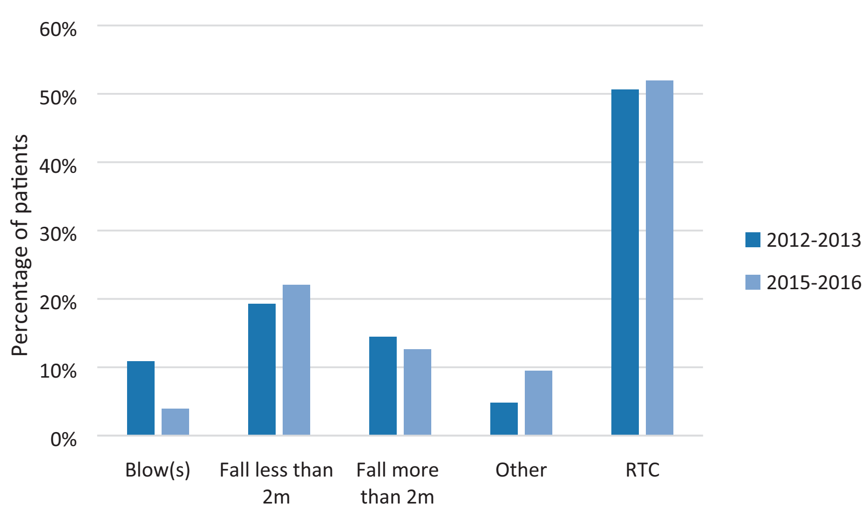

Figure 2. Percentage of patients by mechanism of injury. RTC: road traffic collision.

Table 2. Percentage of children who had a CT neck for CSI at major trauma centre (MTC) and trauma units (TUs).

	MTC 2012–2013	MTC 2015–2016	TU 2012–2013	TU 2015–2016	Total
ISS 1–8					
n	200	257	304	329	1083
Scanned (% of total)	32 (16.0%)	36 (14.0%)	26 (8.6%)	25 (7.5%)	119 (11.0%)
CSI (% of scanned)	4 (12.5%)	8 (22.2%)	4 (15.3%)	10 (40.0%)	26 (21.8%)
ISS 9–15					
n	881	1068	1481	1401	4831
Scanned (% of total)	113 (12.8%)	90 (8.4%)	62 (4.2%)	59 (4.9%)	324 (6.7%)
CSI (% of scanned)	7 (6.1%)	5(5.5%)	12 (19.3%)	11 (18.6%)	35 (11.1%)
ISS > 15					
n	684	813	447	491	2515
Scanned (% of total)	286 (41.8%)	332 (40.8%)	103 (23.0%)	84 (28.9%)	994 (32.5%)
CSI (% of scanned)	24 (8.4%)	52 (15.6%)	11 (9.7%)	15 (17.8%)	102 (12.7%)
Total	1765	2138	2232	2221	8429
Total scanned	431 (24.4%)	458 (21.4%)	191 (8.5%)	168 (7.5%)	1238 (16.1%)
Total CSI	35 (8.1%)	65 (14.2%)	27 (14.1%)	36 (21.4%)	163 (13.2%)

CSI: cervical spine injury; CT: computerised tomography; ISS: injury severity score.

Table 3. Total numbers of children who had a CT scan during both periods.

Age		0–1 yrs	1–2 yrs	2–3 yrs	3–4 yrs	4–8 yrs	8–12 yrs	12–16 yrs	Total
Total	2012–2013	600	335	393	263	661	711	1093	3997
	2015–2016	673	312	404	280	741	783	1166	4359
Scanned	2012–2013	36 (6%)	35 (10.4%)	34 (8.7%)	30 (11.4%)	99 (15.0%)	137 (19.3%)	251 (23.0%)	622 (15.3%)
	2015–2016	35 (5.2%)	21 (6.7%)	25 (6.2%)	42 (15%)	92 (12.4%)	133 (17.0%)	268 (23.0%)	616 (14.1%)
Injured	2012–2013	8 (1.3%)	1 0.3%)	2 (0.5%)	4 (1.5%)	6 (0.9%)	12 (1.7%)	29 (2.7%)	62 (1.5%)
	2015–2016	9 (1.3%)	5 (1.6%)	6 (1.6%)	7 (2.5%)	16 (2.2%)	16 (16.0%)	43 (3.6%)	101 (2.3%)

CT: computerised tomography.

with *higher rates of children diagnosed with CSI on imaging*. This was true when adjusted for injury score. TUs had a higher chance of picking up CSI in children with all injury scores across both time periods (Table 2).

Comparing age groups, there appears to be a wide spread in the accuracy of tools applied for different age groups with the absolute numbers of very young children who are injured, or scanned, being small (Table 3). In 2012–2013, only eight children under one year were registered with TARN as having a CSI, and only 28 more were scanned. This could reflect high thresholds for scanning in this age group, or more likely, the types of injury they present with. The numbers are even less impressive for the 1–2 year old age group, with just one injury and 34 other scans in 2012–2013. The highest increase in positive scan rates were in the 1–2 year old age group (20.9) and the second in the 2–3 (17.6) year old age group.

Discussion

In this time series of children and young people presenting to TUs and MTCs as part of the TARN network, the use of imaging has slightly reduced over time with an increase in the proportion of positive scans. With current resources and technologies it would be impossible to avoid irradiating all children who have no C-spine injury, but these data support progress in more consistent clinical examination and radiology. It will be a subject of debate that 83.6% of children in this data set received high risk radiation to the neck and had no injury, and whilst a 6.6% increase in positive scan rates is clinically significant, continued improvement should be the aim.

Most clinicians would not be satisfied with an only 80% chance that CSI had been excluded in high risk children on initial radiological examination, and this is reflected in updated guidance.[7] This rate is unlikely to be due to poor reporting, as in the 1234 scans reported over the two periods, only three fractures were missed (0.24%). All other undiscovered injuries were ligamentous or cord contusion.

Introduction of early MRI for children with high suspicion of CSI may result in higher diagnostic acuuracy[8,9] but in practice it might be difficult to decide when to scan. Severely injured patients can have a relatively fast CT scan prior to theatre, often in a location close to the Emergency Department. However, putting such a patient into a closed scanning system such as an MRI for 20–40 min, without getting an immediate report, is a clinical risk. A different approach is to consider if X-rays are unable to fully clear the spine, and there are significant suspicions about CSI, patients will remain immobilised until awake. At that point requesting an urgent MRI (within 24 h, or prior to extubating) might be more practical, as well as more sensitive, than an early CT scan.

However, a child who has a clinically clear neck fracture may need to go to theatre urgently, and so a CT in this case may be easily justified by surgeons looking for quick and clear delineation of the bony anatomy. This is more likely to happen in an MTC, with a different subset of professions having the discussion.

Why there should be such variance in practice between MTCs and TUs, as reported in these data, remains unclear. It is possible that trauma services have been developed with an emphasis on getting patients into the scanner quickly and efficiently. Whilst this strategy has been effective in its aim, an undesirable effect may be that more patients are being scanned who are less likely to be injured.

This data set does not appear to support the premise that younger children sustain injuries at higher cervical spine levels[10,11] (Table 1) – the hypothesis being that the relatively larger head causes the cervical spine fulcrum to be at a higher level – with injuries spread reasonably evenly across all age groups. However, it is difficult to be certain since the level was unknown for 27% of cases which may have skewed the results.

Differences in positive scan rate may reflect guidance being most useful in those who are most difficult to examine; a frightened toddler is challenging for any practitioner to assess. Positive rates also increased for teenagers, who are most likely to have an injury (4.4%), which does suggest that the guidance as a tool is genuinely useful at increasing predictive rates of CSI. However, any changes in the data for very young children would need to be evaluated over a longer time period in order for the effect size to be quantified with any accuracy.

It is not possible to attribute with any certainty the use of the NICE guidance in bringing about these changes. However, over such a short period it is unlikely that CT availability is the cause, patient characteristics appear similar, and the data were collected in the same way. Given that the purpose of the guidance was to improve CT scan usage, and the guidelines are widely available and used by both radiologists approving scans and clinicians requesting scans, it seems reasonable that the change in guidance has at least contributed to the change in practice. It is important to recognise any impact on clinical practice and on patient outcomes in relation to such changes, as not all recognised benefits will be realised. In addition, anticipated harms may manifest themselves in greater proportion. However, when guidance proves to be valuable and useful, improving outcomes as planned, advertising this is likely to increase uptake and adherence. Further data collection will continue to see if this change is sustained, and when the plateau of effect takes place.

Conclusion

Changes in guidance for ordering scans have impacted the detection rates of CSI in children in a positive way, meaning that the decision making process is developing higher sensitivity.

However, there remain a proportion of children whose injuries are not apparent immediately because the injuries were ligamentous or cord contusion and therefore the role for early MRI in children with suspected spinal injury still needs exploration.

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Contributorship

CN developed the first draft and edited. SN helped analyse the data and sited the manuscript serially. TL provided the initial data analysis. FL and DR edited the paper.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ORCID iD

Catherine Nunn https://orcid.org/0000-0001-5995-0957

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Supplemental material

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