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Have changes in CT guidance positively impacted detection of CSI in children?

A review of TARN data

Background:

Significant injury to the cervical spine (CSI) in children is uncommon in the UK; present in 1.6-2.3% of seriously injured children[3,4]. 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 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[5,6]. Computerised Tomography (CT) of the neck is quick, easily performed in conjunction with a head CT, and is largely available. It also has a relatively high radiation dosage and which has been shown to significantly increase the likelihood of tumours in children.[7,8, 9] 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.

The national institute of clinical excellence (NICE, United Kingdom) have produced guidance aiming to simplify the decision making process and reduce potential radiation dosage to children. In 2014, that guidance in relation to the use of CT neck scans in trauma was updated for children with head injury, **meaning a CT neck wasn't automatically indicated with a CT head.**

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

- GCS < 13 on initial assessment
- Intubated
- A definitive diagnosis of CSI is urgently required
- Other areas are being scanned for head injury or multi-region trauma

- Focal neurological signs
- Paraethesia 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. [10]

We sought to evaluate the impact the new guidance has had.

Methods:

The Trauma Audit & Research Network (TARN) routinely collects data about paediatric major trauma patients – including those with cervical spine injury (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 were under 16, presented to a MTC or a TU in England during the study periods and met the TARN inclusion criteria of requiring either critical care, an inter-hospital transfer for ongoing acute care, a stay of more than 3 days, or die after arrival.

Data was collected on all patients under 16 presenting to trauma receiving hospitals in England in 2012-3 pre guidelines and during 2014-5 after the 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 C spine injury. The report of their CT scan and subsequent MRI scans were also analysed. We excluded 16 transferred patients from the final analysis, 9 of who had neck imaging and 7 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 2012-13 4694 injured children were included in the TARN database, which increased by 7% in 2015-16 to 5011. In the first period 83 children had a c-spine injury of any kind, 1.8% of the total population included. In the second period, 127 children had sustained c-spine injury, increasing the proportion to 2.5%. Total CT scan rates decreased from 643 to 609 (13.7% to 12.2%), but this was not statistically significant.

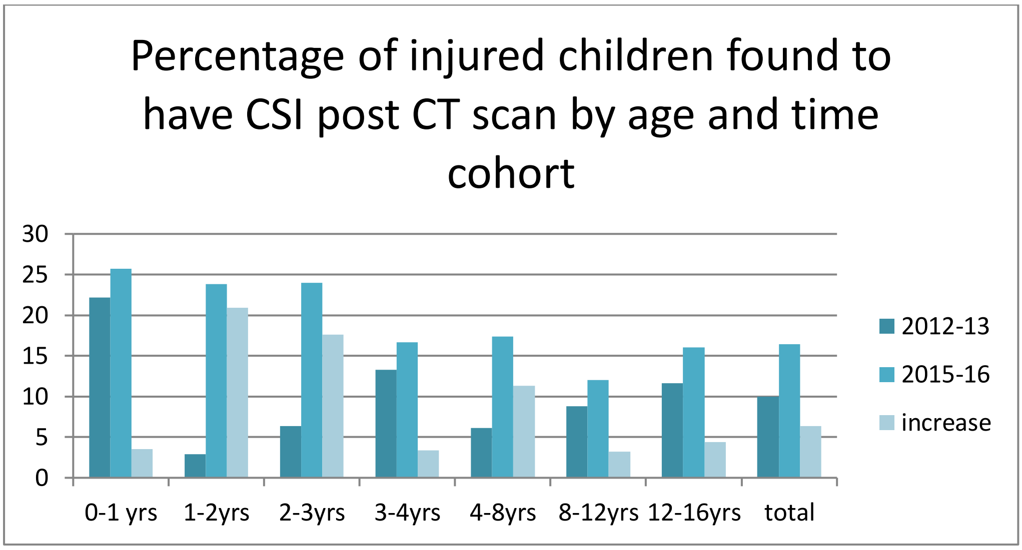
Table 1 Age and level of vertebral injury

Age & level of vertebral injury	**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**

Teenagers were most likely to have sustained a CSI, with 39 (3.1% of teenage major trauma cohort) injuries in the first cohort 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.

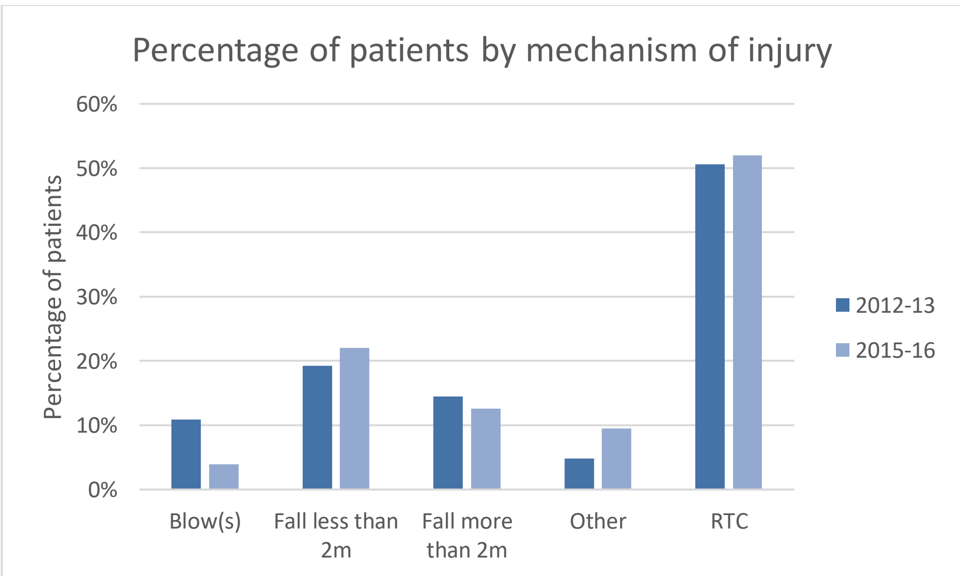
Rates of CSI in those children initially imaged with CT changed significantly from 10% to 16.4%, and although the trend was reflected across almost all age groups this was not evenly spread (Fig 1). The percentage of CSI in 2-3 year olds showed the biggest increase with CSI rates increasing from 2.9% to 23.8%.

Fig. 1



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. Falls were the next most common, with few injuries being caused by blows or "other" mechanisms (including horses), and only one caused by stabbing.

Fig 2.



Not all CSI was identified at 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 with higher rates of children with CSI being imaged. 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).

Table 2. Percentage of children who had a CT neck for CSI at MTC and TU

ISS	MTC 12-13	MTC 15-16	TU 12-13	TU 15-16	Total
1 - 8					
n	272	319	314	335	1240
Scanned*	49 (18%)	43 (13.5%)	31 (9.9%)	34 (10.1%)	157 (12.7%)
CSI**	9 (18.4%)	13 (30.2%)	4 (12.9%)	10 (29.4%)	36 (22.9%)
9 - 15					
n	1089	1340	1542	1433	5404
Scanned	162 (14.9%)	115 (8.6%)	68 (4.4%)	66 (4.6%)	411 (7.6%)
CSI	13 (8%)	11 (9.6%)	13 (19.1%)	11 (16.7%)	48 (11.7%)
> 15					
n	1013	1086	464	498	3061
Scanned	375 (37%)	392 (36.1%)	124 (26.7%)	103 (20.7%)	994 (32.5%)
CSI	33 (8.8%)	67 (17.1%)	11 (8.9%)	15 (14.6%)	126 (12.7%)
Total n	2374	2745	2320	2266	9705
Total Scanned	586 (24.7%)	550 (20%)	223 (9.6%)	203 (9%)	1562 (16.1%)
Total CSI	55 (9.4%)	91 (16.5%)	28 (12.6%)	36 (17.7%)	210 (13.4%)

***% if of n**

****% if of those scanned**

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. In 2012-13 only 8 children under 1 year were registered with TARN as having a c-spine injury, 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 significant for the 1-2 year old age group, with just 1 injury and 34 other scans in 2012-13. The highest increase in positive scan rates were in the 1-2year old age group (20.9) and the second in the 2-3 (17.6) year old age group.

Table 3. Total numbers pf 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
	2015-2015	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%)

Discussion:

In this time series of children and young people presenting to Trauma Units and Major Trauma Centres as part of the TARN network, 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 this data supports 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 both clinically and statistically 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[9]. This rate is unlikely to be due to poor reporting, as in the 1234 scans reported over the 2 periods, only 3 fractures were missed (0.24%). All other undiscovered injuries were ligamentous or cord contusion.

Introduction of early MRI for children with high suspicion of C-spine injury may result in higher diagnostic accuracy 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 minutes, 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 cervical injury, patients will remain immobilised until awake. At that point requesting an urgent MRI (within 24 hours, or prior to extubating) might be more practical, as well as more sensitive, than an early CT scan. **However, a child who has an 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 a trauma centre, with a different subset of professions having the discussion.**

Why there should be such variance in practice between MTCs and TUs, as reported in this 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[4, 11] (table 1) – the hypothesis being that the relatively larger head causes the cervical spine fulcrum to be at a higher - with injuries reasonable evenly spread across all age groups. However, it is difficult to be certain since the level was unknown for 27% of cases and this 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 was 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. 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.

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