

Cervical spine trauma radiographs: Swimmers and supine obliques; an exploration of current practice

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ABSTRACT

The study objectives were: to investigate current cervical spine radiographic imaging practices in conscious adult patients with suspected neck injury; reasons behind variation and consideration of dose estimates were explored. Comparison with a previous survey¹⁹ has been made.

Questionnaires were sent to superintendent radiographers responsible for accident and emergency X-ray departments in English trusts with over 8500 emergency admissions per year, with a response rate of 97% ($n = 181/186$).

Departmental cervical spine imaging protocols were reported by 82% of respondents. None use fewer than the three standard projections; if the cervicothoracic junction (C7/T1), is not adequately demonstrated 87% use swimmers projections, 9% supine obliques, 3% CT alone. Following projectional radiography, 97% perform CT. A significant ($p = 0.018$) increase was found since 1999¹⁹ in CT use once the swimmers projection fails; fewer now use obliques at this point, continuing with CT instead. No significant difference ($p = 0.644$) was found in choice of first supplementary radiographs; despite British Trauma Society's¹¹ recommendation to undertake supine obliques, swimmers remain the most widespread technique.

An 85% response rate ($n = 103/121$) completed a second questionnaire, exploring reasons behind the various practices. Several reported a perceived difficulty in interpreting oblique radiographs, some a concern over high dose of the swimmers.

Numerous issues affect the acquisition of cervical spine radiographs. Patient radiation dose should be a major consideration in selection of technique. A potential need for training in interpretation of obliques is highlighted. Specific guidelines for optimum projections should be researched, and protocols issued to ensure best practice.

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Introduction

Patients with suspected cervical spine injuries are assessed on arrival at hospital. The presence of high risk factors means imaging must be undertaken to exclude clinically significant injury,^{1,2} providing “justification” of imaging as required by legislation.³ Imaging of patients with neck injuries in National Health Service (NHS) hospitals has long been, and (with the exception of the unconscious patient) continues to be, three good quality radiographs⁴ of the cervical spine; AP, lateral, and odontoid peg projections. The cervicothoracic junction (C7/T1) can be difficult to see on the lateral X-ray. As a result additional techniques may be used to supplement the initial series of three radiographs when necessary. Alternatives available comprise the swimmers projection, supine

obliques, and collimated true lateral projections (CTL). Computed tomography (CT) scanning is also used as an alternative or supplement to radiographs. Reviewers have found very little evidence^{5–9} published to direct practitioners as to which supplementary projection to select. Patient's radiation dose is markedly higher with the swimmers projection than other plain radiographic methods^{5,11–13} and movement of patients with suspected neck injuries may be unsafe^{5,11,14,15} which raises doubts over the use of the swimmers projection. In addition, image quality issues have been raised in swimmers projections.¹⁶ Oblique projections have been criticised as hard to interpret¹⁷ although others disagree.^{5,18} Jenkins, Curran and Locke¹⁹ undertook a survey into the techniques in use to show C7/T1; they stated that supine obliques give better information about spinal alignment, with less radiation of the patient.

This study investigated, and explored justifications for, the practice variations and differences in protocols used within imaging departments in English NHS Trusts and compared findings with Jenkins et al's work.

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Method

There were two phases in the research:

- (i) A postal questionnaire to establish current practice in English NHS Hospitals for C7/T1 demonstration in conscious adult trauma patients.
- (ii) A follow-up questionnaire to explore practitioners' justifications for the protocols in use.

In line with Dillman's (2006) Tailored Design Method²⁰ questionnaires were personally addressed where contact names could be identified, otherwise the addressee was simply the "A&E X-ray Superintendent". A large cohort of 186 hospitals was selected to try to achieve a representative sample, minimising sampling errors. The 186 hospitals were all the hospitals in England with over 8500 accident and emergency (A&E) admissions yearly.²¹ Pilots of the questionnaires were undertaken at busy Welsh A&E hospitals for evaluation without prejudicing the intended population.

Ethics and potential impact

Ethics approval was granted by University Ethics Committee. The National Research Ethics Service communicated that the project constituted a service evaluation (personal communication, 6 Nov 2008) and therefore multiple local trust ethics board approval was unnecessary. Only anonymised data was reserved for publication. Assurance was given to respondents of the voluntary nature of the research and the confidentiality and security of their responses in covering letters. Any personal data storage was on secured, password protected hospital computers, with email communication via the highly encrypted NHS Mail system.

Data Collection

The initial questionnaire posed three main questions:

1. Does the department have a protocol for clearing the C-spine?
2. Which techniques are routinely taken in the conscious adult patient with a suspected neck injury, and in what order?
3. Is there a computed tomography (CT scanner in the department or hospital and does the Accident and Emergency Department have access to it?

Consent was also sought for willingness to complete the second questionnaire which was designed to try to establish themes behind variations in practice.

Results

The initial response rate was 97% ($n = 181$ of 186 radiographers contacted). All routinely undertake a minimum of three standard radiographs (AP, lateral and AP odontoid) of the conscious adult patient with a suspected neck injury.

If the C7/T1 junction cannot be visualised on the initial lateral projections, the first additional imaging acquired in 157 (87%) of hospitals is a swimmers projection. Seventeen (9%) departments undertake supine oblique projections as first choice. A recent development is the use of CT scanning as the first additional imaging method, reported at five (3%) of the sites. These details are represented in Table 1.

Most ($n = 149/181$, 82%) have a protocol for "clearing" the C-spine, four ($n = 4/181$, 2%) declined to answer and 28 (15%) stated that they did not have such a protocol. Several sites indicated they

Table 1
first questionnaire results.

Sample = 186 Responses = 181 (97%)
0 (0%) departments used < 3 views for clearing the cervical spine.
<ul style="list-style-type: none"> • 178 (99%) hospitals have a CT scanner • Of which, all A&E departments) have access to it.
<i>First technique to supplement</i>
157 (87%) use Swimmers ^a
17 (9%) use Obliques ^a
3 (2%) use Collimated True Lateral
5 (3%) use CT

^a 1 site uses either swimmers or obliques 1st, (depending on patient status/habitus: counted in both totals).(All % to nearest whole no.)

understood clearing the C-spine to be a clinical undertaking or that the A&E department (not imaging) hold the protocol.

If the C7/T1 junction still cannot be visualised, the vast majority ($n = 143/181$, 79%) proceed immediately with CT scanning after failure of the supplementary projections; and 26 ($n = 26/181$, 13%) continue with supine obliques (following the previous swimmers) prior to CT. Others not proceeding immediately to CT, include those using swimmers after obliques ($n = 4/181$, 2%). Other sites ($n = 5/181$, 3%) using CT, undertake no supplementary radiographs and use CT alone to correct for non-visualisation of C7/T1. These details are represented in Figs. 1–3.

Almost all ($n = 178/181$, 99%) imaging departments surveyed have a CT scanner that the A&E department can normally access. One of the two sites without a CT scanner available was a Minor Injuries Unit; two others referred to a "main site" where CT scans were undertaken. Three further sites did not indicate that CT would be undertaken as a "last resort" to demonstrate the cervicothoracic junction, one indicating that oblique projections are a sufficiently effective "last resort" to rule out the use of CT simply to demonstrate C7/T1 when other efforts had failed.

Chi squared (χ^2) tests were undertaken with SPSS version 14.0 (SPSS Inc., Chicago, Ill.). P values below 0.05 were taken to be significant. The findings gave no support for a significant change between choice of first supplementary technique in the current study and the findings in 1999 of Jenkins et al.¹⁹

Even with techniques other than swimmers or obliques excluded from calculations, there was no significant difference ($P = 0.354$) between 2009 and 1999. The χ^2 test results support the null hypothesis, i.e. no significant change in the choice of first technique, for the demonstration of C7/T1 when the initial lateral radiograph fails to, has occurred between 1999 and 2009.

Further χ^2 testing was undertaken on these data to examine the possibility of significant change in the next option, following failure

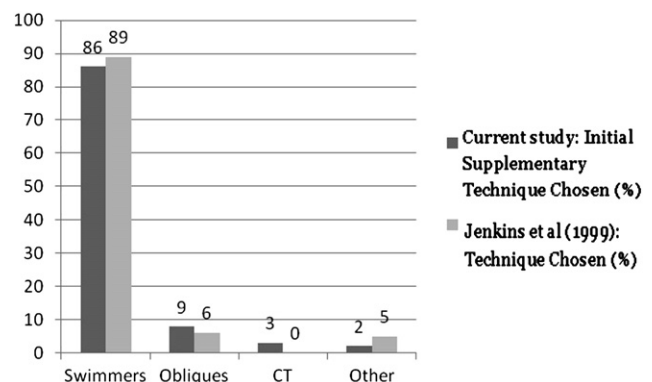


Figure 1. Comparison 2009/1999.

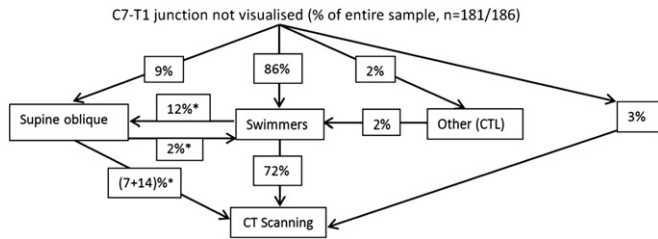


Figure 2. Imaging Pathways of 2009.

of the swimmers projection, to show C7/T1. A strongly significant change was found ($P = 0.018$) between the practices in 1999 and the current study; fewer radiographers now undertake oblique projections following failure of the swimmers, a higher proportion continues immediately with CT. The results are displayed in Fig. 4, with comparison of the numbers of sites choosing CT or obliques next, following a failed swimmers projection (or projections).

Patient radiation doses

The doses from the various radiographic examinations were considered with particular reference to the figures quoted in previous papers^{5,22} and the risks of thyroid cancer in the work by Shu et al. (2006).²³

A practical example of the doses in current use incurred in cervical spine imaging is provided in Table 2.

2nd Survey

The second survey was posted to only those 121 hospitals that had indicated, on their first responses, a willingness to complete the longer (and more qualitative) second questionnaire. The response rate was 85% ($n = 103/121$). χ^2 testing was applied to yes/no questions. A null hypothesis of no significant differences between the sites undertaking trauma obliques and the sites choosing swimmers was supported; no significant differences were found between answers on the opinions of the practitioners on the issues of: demonstration of anatomy, safety, minimisation of dose, demonstration of alignment, rapidity and interpretability.

One statement: “The technique gives the lowest radiation dose that is reasonably achievable” elicited agreement from 51% of those undertaking swimmers versus 79% of the sites using trauma obliques. This stood out as the only percentage score that appeared greatly different between the techniques, but the P -value of 0.058 was significant at 94.2% level, and thus close to, but not meeting, the conventional 95% significance level.

This finding sits alongside previous,⁵ which found “a substantial reduction for a pair of supine oblique views (1.6 mGy) over a single swimmer’s view (7.2 mGy)” (p151) and the dose calculations in

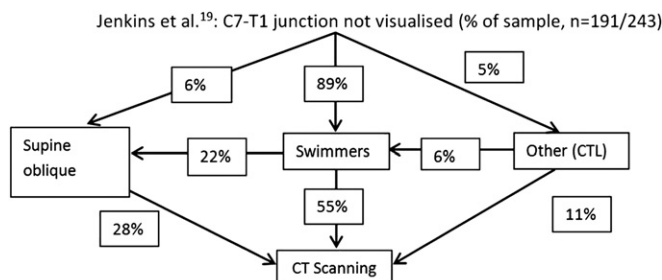


Figure 3. Imaging Pathways of 1999.

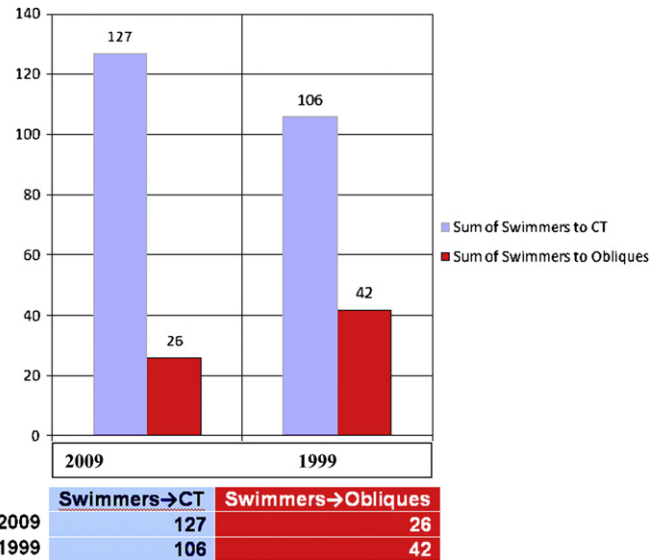


Figure 4. Next Projections used when swimmers fails, 1999 and 2009.

Table 2: the swimmers gives 2.5 times the equivalent exposure of a pair of oblique radiographs.

The only conclusion drawn from the “Yes/No” answers to the second questionnaire then is that respondents felt about the same about most issues; but that those undertaking swimmers projections showed feelings, close to significance, that their chosen technique is less likely to be the method with the lowest dose achievable.

The second questionnaire probed the respondents’ opinions of the confidence of the reporting officers (i.e. reporting radiographers and/or radiologists) for the issuing of reports and of the referring doctors’ confidence in interpreting radiographic series including the supplementary techniques in use. The questions then, established what the respondents thought other people’s confidence is.

The findings are presented in Figs. 5 and 6 which show the sums of the respondents’ opinions of confidence of the referring doctors and reporting officers in interpreting images with each technique. Spearman’s Rank Correlation was applied to the data. A significant correlation (correlation coefficients = 0.845 for swimmers and 0.763 for obliques, both $P = 0.01$ for a 2-tailed hypothesis) was found for both the swimmers and oblique techniques between the perceived confidence of imaging staff reporting and referring doctors (N.B. – in this survey, the response “1” represented highest and “5” lowest confidence.).

A conclusion for the issue of confidence in interpretation of the images is that: for both techniques, confidence of imaging staff reporting is associated with a correlation of the referring doctors’ confidence in interpreting the same images. This is in agreement with previous research⁵ that swimmers and obliques both provide similar information on the C7/T1 junction.

Table 2

Effective Dose, Cancer risk and equivalent background radiation exposure (C. Woods, personal communication, 6th May, 2009).

Projection	Dose (mSv)	Approximate risk of fatal cancer	Equivalent background for each single exposure (days)
Lateral	0.02	1 in 1,000,000	2.7
AP	0.04	1 in 500,000	5.4
Oblique (each projection)	0.04	1 in 500,000	5.4
Odontoid	0.06	1 in 330,000	8.1
Swimmers	0.2	1 in 100,000	27
CT	2.2	1 in 9000	297

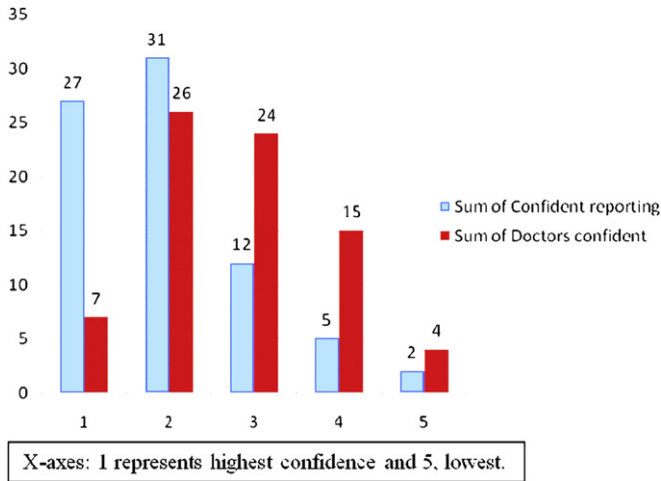


Figure 5. Swimmers; sum of opinions of confidence.

Results summary

The results include details of the findings of the two questionnaires. A comparison is made with previous findings.¹⁹ Statistical analysis of the data and evaluation of any significant findings within, and in comparison with the results from 1999, is presented. In summary, six main points are detailed:

1. All x-ray departments surveyed use a minimum of three projections to demonstrate the cervical spine in alert adults with suspected neck injury.
2. 99% of sites ($n = 178/181$) now have CT available, A&E having access at all of them; more than 1999 when 183 (96%) hospitals had scanners, but only 178 (93%) had access to them.
3. No significant change since 1999 was found in the first supplementary technique chosen to show C7/T1. A small, but perhaps notable, exception being the 3% ($n = 5/181$) of sites employing CT as first recourse.
4. A significant change ($P = 0.018$) in the choice of second supplement has been found, fewer sites employ obliques and more use CT as next choice if a swimmers projection fails to show C7/T1.
5. The doses involved in the possible choices are detailed, swimmers giving a markedly higher dose than other radiographic projections. Many practitioners (approaching a significant level) feel that the swimmers projection is not the lowest dose option. These two points can be triangulated with the literature.^{5,10}

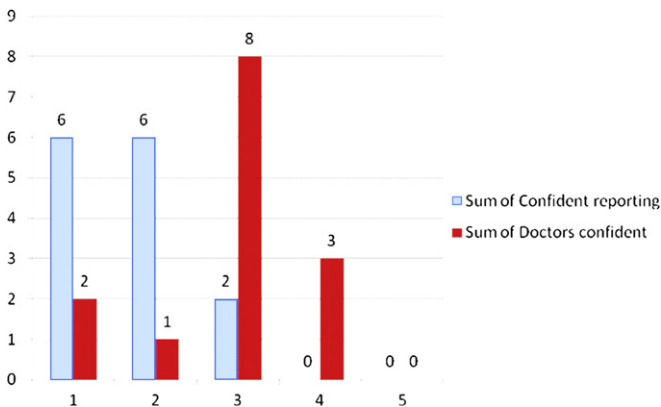


Figure 6. Obliques; sum of opinions of confidence.

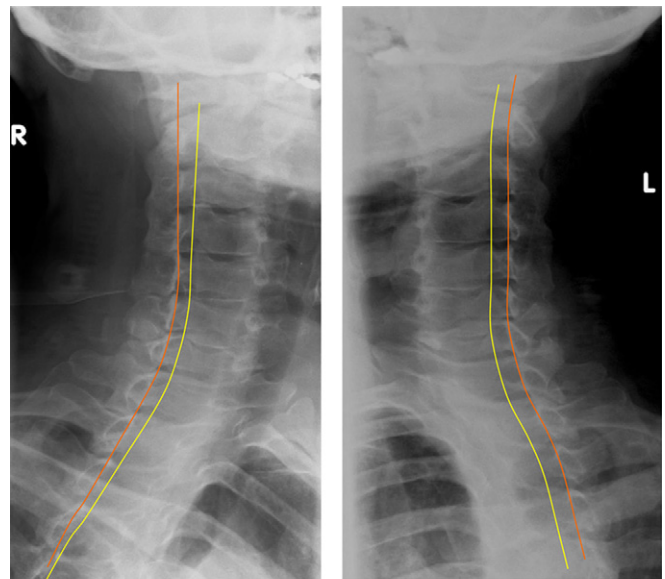
6. A significant correlation ($P = 0.01$) between the perceived confidence of referring doctors and reporting officers was found regardless of the technique in use, echoing previous findings⁵ that no significant difference exists in the capacity of obliques and swimmers projections to show C7/T1.

Discussion

This study integrated mixed methods, in an area where quantitative methods alone are predominant. Qualitative data enriched the research and provided those not culturally engaged (e.g. non-radiographers) with a deeper understanding of the quantitative findings. The required information on what projections and why they are used did not appear to be obtainable without a mix of methods and seeking opinions from practitioners. The opinions were sought were those of A&E X-ray superintendents working in English NHS hospitals with over 8500 emergency admissions per year.

The current survey was informed by Jenkins, Curran & Locke's work undertaken in 1999.¹⁹ Developments since then include the guidelines from the British Trauma Society (BTS),¹⁰ NICE guidance⁴ on head (and neck) injury and the technological advances with computed tomography. The results, with results from Jenkins et al.¹⁹ for comparison, are depicted in the Figs. 1–3.

The work of Ireland and colleagues⁵ in 1998 remains the single piece of evidence to inform practitioners as to which supplementary radiographic projections might be best, no other such work has been found by the author or in the review papers on the topic.^{6–9} Ireland et al.'s⁵ work concluded equivalent imaging capabilities of the swimmers and oblique alternatives, with a saving of dose and sparing the risk from movement with the obliques; their paper also provides a useful, labelled illustration of the radiographic anatomy displayed, and further illustrative guidance is offered below with paired obliques.



Paired obliques: Alignment should be checked along the posterior aspects: orange line – laminar line, there should be "roof tiling"; yellow line – alignment of posterior vertebral margins.

With the advent of the NICE Head Injury Guidelines⁴ and the section referring to cervical spine injury, it may be expected that many will employ the criteria within that guidance, which appears to rely more heavily on the Canadian Cervical Spine Rule⁷ rather than the earlier NEXUS² guidance.

In England, all radiographers working to investigate suspected neck injuries, in alert conscious adults, now take a minimum of three projections. This is an improvement from the situation found in 1999,¹⁹ when only 93% of centres studied used the three standard projections as a minimum. This change in practice fits with the NICE guidance⁴ to obtain “three-view plain radiography” (p45). Sensitivity for the three projection series has been quoted at “up to 92% in adults”⁹ (p257) and “a negative predictive value for a three view series has been quoted as between 93 and 98%.”⁴ (pp111–112) compared with 82–85%⁹ for the lateral alone, although lower sensitivities have been found. Studies^{6,25} report lateral projections alone miss more injuries than three projections. A 1989 paper found nearly one third of hospitals relying solely on a lateral film.²⁶ The change in twenty years from one third using only lateral radiographs (USA), to 93%¹⁹ and now 100% (UK) shows healthcare providers have acted according to evidence in choosing their protocols. CT scanning is viewed as the “gold standard” with a sensitivity of 98.8%²⁷ and 99.2%²⁸ and 90–100%²⁹ having been quoted. Daffner and Hackney warn sensitivity estimates for plain radiography “represent maximums and may overstate the reliability of radiography”³⁰ (p763) as no CT was undertaken.

If the cervicothoracic junction is not adequately demonstrated, the majority of hospitals ($n = 155/181$, 86%) continue to obtain swimmers projections, before going on to CT if C7/T1 is still not shown. This compares very closely to the practice ten years ago, when 89% ($n = 170/191$) reported use of the swimmers projection as the first supplementary technique, no statistically significant difference was found. This high proportion of centres obtaining swimmers projections has persisted over the last ten years in spite of evidence to suggest “that supine oblique views provide better information with less radiation of the patient”¹⁴ (p216). The use of the swimmers projection continues regardless of the recommendations of the BTS¹¹ guidelines of 2003 that: “If the cervicothoracic junction is not adequately seen, oblique views or a coned penetrated view may be considered, before resorting to a CT scan of this area” (p411). The swimmers projection has been criticised as giving a higher radiation dose than the plain radiographic alternatives,^{5,11,13} for being difficult to reproduce adequately; a recent study¹⁶ found only 55% of swimmers radiographs of sufficient diagnostic quality. The movement required can bring further attendant dangers^{1,11,14,15} and the possibility of exacerbating an injury is risked.

The free text responses from the second questionnaire revealed some justifications from current practitioners for the persistent use of swimmers projections. Comments that the referring clinicians find swimmers views simpler to interpret than obliques were common; 33 of the 44 offering opinion supported this in free text responses, although many respondents offered no free text opinion on comparative ease of interpretation. For the closed response option, considering only those 78% ($n = 79/101$) of the respondents to the second questionnaire using swimmers as first choice: “Easiest for A&E Staff to interpret” was selected by 69% ($n = 56/81$). The other respondents to the second questionnaire did not use swimmers as first option. Of those 14% ($n = 14/101$) using obliques as the first supplementary technique, that responded to the second questionnaire, “Easiest for A&E Staff to interpret” was selected by only 43% ($n = 6/14$) however this difference was not statistically significant ($p = 0.952$). For CT, 50% ($n = 2/4$); Collimated True Lateral (CTL) 66% ($n = 2/3$). Those undertaking supplementary projections in the lateral plane (i.e. swimmers or CTL) appeared then, by simple comparison of percentage of responses, to hold the belief that such radiographs offer a more straightforward option for the referring doctor to interpret; although no significant difference was found with χ^2 testing. This situation was further supported by analysis of the questions on the second questionnaire where

respondents indicated their opinion of the confidence of reporting officers (i.e. radiologists and reporting radiographers) in interpreting the radiographs used at their hospital, no significant change was found, in the measure where swimmers projections were used, from that where the obliques were used. These two findings can be seen as having validity when triangulated with the report of Ireland et al.⁵ (1998) who found the techniques of equal value for interpretability: “swimmer’s views and supine oblique views show the alignment of the vertebral bodies with equal frequency” (p151).

Clinical and radiological clearance of the cervical spine continues to be difficult with great risks to be overcome, the large proportion (82%) of departments declaring a protocol for this is reassuring. Many departments have protocols recognising the need to limit the doses delivered to their patients, it was common to find comments from the respondents outlining maximum limits of one or two attempts at the swimmers projection prior to selecting an alternative, usually CT ($n = 143/181$, 79% choosing CT) or in some instances obliques ($n = 26/181$, 13%). The increased use of CT scanning should be recognised for its value in the detection of abnormality but strenuous efforts to reduce dose by evidence based rules and by protocol optimisation,²³ must be made.

Recommendations

This research has not established how it is that accident and emergency departments arrive at the decision to refer for imaging. Further study in this area, involving a survey of the practitioners and referrers and a literature review, would be useful to establish which decision rules the NHS hospitals are using to decide who to refer for neck imaging in trauma, especially in the alert and conscious adult.

A qualitative, interview and observation based study is recommended for further validation of investigation into radiographic techniques to demonstrate C7/T1 and ascertain the confidence of those who need to interpret the radiographs. Thematic analysis of transcriptions of the thoughts of such health professionals would provide an understanding of the practical issues involved in the important and difficult job of clearing the cervical spine. This study could combine with the investigation of the decision rules in use.

There is certainly a need for further investigation into this issue; the replication of Ireland et al’s⁵ prospective comparative method would be of value, to increase the number of subjects and the accuracy of conclusions. A randomised controlled experiment is seen as a higher level of evidence.²⁴ Ethical approval for such a comparison of swimmers and obliques should be possible, as there is no current evidence to support one technique over the other.^{6–9}

There remains a pressing need for current guidelines to be extended to assist physicians to rapidly determine how the C-spine can be best cleared in the large group of adult patients that require imaging but are alert and conscious.

Conclusions

This study has established current practice in the radiographic demonstration of the cervicothoracic junction within English NHS Trusts. The key factors of image quality, dose and patient safety have all been considered. Exploration has been made into the qualitative opinion of practitioners and there has been quantitative enumeration of practices, with comparison made to a previous survey. Swimmers still remains the favoured supplementary projection in the vast majority of trusts, despite the higher radiation dose to patients. It is recommended that further research is undertaken to establish the optimum projection (considering the key factors listed above) that demonstrates C7/T1 in the adult conscious patient with suspected neck injury. It is recognised that if

obliques are found to be the ideal, further training and support will be needed for those who are unfamiliar with the technique and lack confidence in interpreting the images obtained by this method.

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