DEMONSTRATING THE CERVICOTHORATIC JUNCTION ON FILM: AN ALTERNATIVE TO THE SWIMMERS.

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Abstract

This study was conducted to ascertain which of two techniques would result in more diagnostic films of patients with possible neck trauma. Twenty individuals were examined at the Radiology Department, Universitas hospital, Bloemfontein. Two exposures were done on each member of the sample: firstly the swimmers projection and secondly the orientation of the patient's arms was reversed.
Using specific criteria to standardize evaluation, the films were evaluated by a radiologist. The adapted swimmers projection had better results in 50% of the categories. The swimmers projection was better in 33.3% of the categories. One category for both projections (16.7%) was equal.

Keywords:
Trauma
Swimmers projection
Orientation
Criteria

1. INTRODUCTION

The radiographic examination of a patient with suspected cervical spine trauma may be difficult and is usually limited to a few projections. The reasons for this are firstly that frequently the patient is unconscious and has associated injuries like pneumothorax/hemothorax, skull injuries as well as injuries of the extremities. Secondly unnecessary movement of such patients increases the risk of damage to the spinal cord (Ahmed, 2003: Online).
The single most important radiographic projection used under these conditions is that of the lateral projection, which includes the first cervical vertebrae (C_1), as well as the first thoracic vertebrae (T_1).

The lateral projection is always done first for all trauma patients because:

- the anatomy under investigation is not moved,
- pathology or possible problems are quickly identified,
- possible intervention can be planned

In essence, the cross-table lateral radiograph should serve only to assess obvious signs of instability and to detect gross fractures and dislocations. It is therefore of the utmost importance that not only the C_7 be visualized, but also to allow us to evaluate the relationship of the transitional architecture between C_7-T_1 vertebrae. The lateral projection (including T_1), may demonstrate obvious pathology or influence further positioning techniques to obtain the rest of the projections: anteroposterior, odontoid and obliques.

In a retrospective study of 740 patients (Davis, 2000: Online), the diagnosis of a cervical spine injury on plain radiographs was delayed or missed in 34 cases. In 10 of those 34 patients, permanent neurological sequelae developed that might have been avoided had the diagnosis been established at the outset.

In radiography, some projections are technically more challenging to perform. The demonstration of the cervicothoracic junction (C_7-T_1), using the swimmers method, heads this list. Daffner (2000: Online) also reported that the swimmer's projection needed to be repeated in 41% of all their patients. Of their study group 34% of the patients required three repeated radiographs and one patient each (2% of the study group) required four, and five repeated radiographs, respectively (Daffner, 2000: Online). In the demanding environment of a trauma department, having to do repeats, is not only stressful for the radiographer, but also life-threatening to the patient, costly and leads to an increase in radiation dose to the patient.

In this study, the researcher sought to ascertain which of the two techniques would result in optimum diagnosis of the cervicothoracic junction more frequently, thereby also increasing diagnosis and minimizing examination time and patient radiation dose.

This study should thus be viewed as an introductory study where the probability of an alternative to the generally accepted way of visualizing the lower cervical spine is of importance.

2. PURPOSE OF THE STUDY

The purpose of this study was to ascertain which of two different techniques [swimmers, adapted swimmers] will allow radiographers and radiologists to obtain the best diagnostic result in the shortest period of time of what is known as “the most commonly overlooked site of injury” (Ahmed, 2003: Online).

3. MATERIALS AND METHODS

B-room at the Universitas Hospital, is equipped with a functional x-ray machine (Siemens Vertix E), x-ray cassettes (Agfa), x-ray films (Agfa–CPG plus) as well as an operational x-ray processor. The x-ray machine was operated at 80% of its capacity. The reliance of the equipment’s performance was underscored by the fact that the machine had a newly installed generator.

To help reduce radiation, 400 speed screens were used. For radiation protection, it was sometimes necessary to use more than 1 wrap-around to ensure that every part of the anatomy was covered. Sensitometry was done to ensure that the processor function does not have an influence on image quality.

The sample that were used consists of 20 individuals. This is a very specific sample: the problem of demonstrating this junction occurs predominantly in patients with broad shoulders. A one cm interval caliper was used for the measurements. Measurements were made in the swimmers position at the level of C_7, just above the jugular notch. Each member of the sample was x-rayed twice:

A. Using the Twinning method of performing the swimmers
B. Reversing the orientation of the arms as was used in (A)

The caliper and standardized exposure chart was used to determine exposure factors. The same exposure factors will be used for both A & B, according to the measurement obtained per individual.

3.1 Positioning

The exposures were done with patient seated, in front of the vertical Bucky grid.

3.1.1 Position of part (swimmers)

- The midcoronal plane of the body was centered to the midline of the grid.
- The patient was moved close enough to the vertical Bucky so that the shoulders can rest firmly against the grid for support.
- The arm that is *closest to* the grid was elevated to a vertical position, the elbow flexed, and the forearm rested on the patient's head
- The height of the cassette was adjusted so that it was centered at the level of C_7-T_1
- The patient's mid-saggital plane adjusted parallel to the cassette and the midcoronal plane was perpendicular
- The patient's shoulder that was *farthest from* the cassette was depressed as much as possible (Bontrager, 2005: 311).

3.1.2 Position of part (adapted view)

- The midcoronal plane of the body was centered to the midline of the grid.
- The patient was moved close enough to the vertical Bucky so that the shoulders can rest firmly against the grid for support.
- The arm that is *farther from* the grid was elevated to a vertical position, the elbow flexed, and the forearm rested on the patient's head
- The height of the cassette was adjusted so that it was centered at the level of C_7-T_1
- The patient's mid-saggital plane adjusted parallel to the cassette and the midcoronal plane was perpendicular
- The patient's shoulder that was *closest to* the cassette was depressed

3.1.3 The following is applicable to both methods

i) Central ray

Directed to the interspace between C_7 and T_1 at an angle of 3 to 5 degrees caudal, depending on the mobility of the shoulder closest to the image receptor (Ballinger & Frank, 1999: 416)

ii) Evaluation criteria

- ✓ Lateral vertebrae, not appreciably rotated
- ✓ Shoulders separated from each other
- ✓ X-ray penetration of shoulder region

iii) Radiographic criteria

- ✓ Vertebral bodies, intravertebral disk spaces, and zygopophyseal joints C4-T3 are shown
- ✓ The humeral head and arm furthest away from the Image recorder is magnified and should appear distal to T_4 or T_5 (if visible) (Bontrager, 2005: 297)
- ✓ Contrast and density are adequate to demonstrate the bony structures of the cervicothoracic vertebrae (McQuillen-Martensen, 1996: 338)

3.2 Important image recording principles for demonstrating C_7-T_1

3.2.1 Object-to-image distance (IOD)

Objects that are further from the image receptor will be magnified. The OID is also a critical distance in both magnification and resolution. First, when objects within a structure are at different levels, they will be projected onto the image as different sizes. To decrease magnification and to improve sharpness, the source to image distance was increased to 180cm.

3.2.2 Air Gap

The modified technique involves placing the patient at a greater object image receptor distance (OID), thus creating an air gap between the anatomy of intrest and the film. By having the anatomy away from the film, the amount of scatter reaching the film will be reduced (Carlton, 2001: 276)

3.3.3 Alignment

Shape distortion can be caused or avoided by careful alignment of the central ray with the anatomical part and the image receptor. Proper positioning is achieved when the central ray is at right angles to the anatomical part and to the image receptor. This means the part and the image receptor should be parallel (Carlton, 2001: 420)

3.3.4 Anatomical Part

The long axis of the anatomical part, or object, is intended to be positioned perpendicular to the central ray and parallel to the image receptor (Carlton, 2001: 422)

3.3.5 Film/Screen Combination

- The specifications of the film used are as follow:
  The film ensures a high contrast in the low densities of the image. This permits the use of Ortho CP-G Plus film in applications such as angiography, where it gives sharp and detailed images of even the smallest blood vessels as well as of bone structures. Even small differences in absorption between soft tissue and air become visible by the varying density levels, thanks to the high conversion efficiency. The Ortho CP-G Plus film is ideal for the imaging of bone structures, allowing even the detection of hairline fractures. The film is also suitable for orthopedics where it will give the finest details of bony structures, yet keeping the soft tissue visible. It is used to detect calcification, early signs of lung cancer and metastasis (Agfa Medical Imaging: Online).

- The specifications of the screens used are as follow:
  CP-G 400, 400 speed screens will be used.
  This means that the amount of phosphor crystals and crystal sizes are high. This also reduces geometric unsharpness (Ball & Price, 2000: 29)

The green light emission of the screens that we are going to use is based upon the GadoliniumOxySulphide phosphor.

The use of the latest technology enables an optimal compromise to be reached between speed and definition, thus ensuring high image quality and a low noise level when used with green-sensitive films (Agfa Medical Imaging: Online).

3.2.6 Motion

- To avoid machine motion during exposure, make sure that all machine-locks are operating optimally.
- Correct immobilization of the anatomical part was employed.

3.3 Comparison of diagnostic quality

The images obtained were given to a doctor (radiologist) for reporting. To exclude possible bias the films were only marked a or b, meaning the doctor did not know the origin of the films. A rubric was used with specific guidelines as to ensure standardization of the evaluation.

A scoring system ranged from 4 to 1 was used:

Table 1 The scoring system

Qualifier	Interpretation
4	**Excellent** Where maximum radiological detection has been achieved.
3	**Acceptable** Where a good diagnosis is achievable

2	**Needs attention** Where possible diagnosis is achieved
1	**Poor** Where a good diagnosis is achievable.

Table 3 Film evaluation rubric

CRITERIA	**FILM A**	**FILM B**
Lateral vertebrae, not appreciably rotated		
Shoulders separated from each other		
X ray penetration of shoulder region		
Contrast and density		
Demonstration of the bony structures of the cervicothoracic vertebrae		
Sharpness		
Total:		

In using the set criteria, the radiologists will compare overall acceptability of the newly proposed technique.

3.4. Statistical analysis

The results from each criterion were tabled. These results were analyzed using Microsoft Excel's Data analysis tool. Descriptive statistics allowed the researcher to evaluate which of the two techniques gave better results. The validity of the hypothesis was also investigated.

4. RESULTS

4.1 Imaging considerations

4.1.1 Measurements

The average measurement of the sample as measured at the centring point, was 32.2cm; median was 32cm and the mode 31cm

4.1.2 Exposures given

The average exposure given for the two views, keeping in mind that the same exposure was given for both, was 75.7kV and 105mAs. The exposure given to the smallest candidate was 75kV and 80mAs and for the biggest one the exposure was 77kV and 125mAs. It must be kept in mind that 400speed screens were used.

4.1.3 Sensitometry

The values obtained for sensitometry, when compared to the values desired (target), were equal to the target values in 3 of the 5 criteria. The variations were all found to be within acceptable limits; for average speed, an acceptable variation is plus or minus 0.15. The same applies to the contrast. (WHO, Quality assurance workbook, 2001: 115)

4.2 Criteria results

4.2.1 Rotation of the vertebrae

For rotation the mean for the swimmers was 2.45 and the mean for the adapted swimmers was 1.8. This can be viewed as less significant – the upper vertibrae was rotated in most cases. Remember that C_1-C_6 should already have been demonstrated on the lateral view.

4.2.2 Shoulder separation

The difference between the shoulder separation with the mean for the swimmers was 2.7 and the mean for the adapted swimmers was 2.4, equals 0.3. If one examines the geometry of the diverging x-ray beam and the centering point, the depressed shoulder (swimmers) would be projected even lower.

4.2.3 Penetration of the C_7-T_1 junction

X-ray penetration was mostly influenced by superimposition of the clavicle and humerus. If one examines the geometry and the centering point again, the raised shoulder (adapted swimmers) would be projected higher. Here the results obtained were better for the adapted swimmers: mean adapted swimmers was 3.35 mean swimmers was 2.15.

4.2.4 Contrast and density

Contrast and density for the adapted swimmers was better then for the swimmers. Keep in mind that these values are mostly subjective; it depends on a wide range of variables including ambient lighting.

4.2.5 Demonstrating C_7-T_1

The difference in visualization of C_7/T_1 was only 0.05 units. This difference translates into 1.25%. In a clinical setting, this percentage, small as it may seem, could mean the difference between making a positive diagnosis of pathology and permanent neurological problems associated with misdiagnosis.

4.2.6 Sharpness of the cortical outlines

Keeping in mind that the same exposures were given for both projections, it was actually very surprising to that the sharpness of the cortical outlines, were evaluated as being equal by the doctor.

4.3 Hypothesis testing

The p-value of the rows and columns, the actual probability of making a Type I error, is larger then 0.1-this protects the researcher from making a serious Type I error (Albright, 1999: 443). The following clarification of p-values is in order:

- ✓ p-value< 0.01 - convincing evidence that the alternative hypotheses (H_1): Reversing the orientation of the arms in the swimmer's view does not increases the diagnosis of abnormalities at C7-T1 transition, is true
- ✓ p-value< 0.05, but >0.01- strong evidence that the alternative hypotheses (H_1), is true
- ✓ p-value< 0.1, but >0.05- moderate evidence that the alternative hypotheses (H_1), is true

The correlation matrix analysis allows us to investigate the relationships between datasets; that is whether they move together.

- ➢ A negative correlation means that small values of one dataset are associated with large values from the other dataset
- ➢ A positive correlation means that large (small) values of one dataset are associated with large (small) values from the other dataset

- A correlation of near 0 means that the datasets are unrelated (Albright, 1999: 92).

There are no extreme values that may otherwise have had an influence on the results obtained. This also means that, even if better results were obtained when the orientation of the arms were reversed, the swimmers method still has a justified place in diagnostic radiography.

5. DISCUSSION AND CONCLUSION

The aim of this exercise as stated in the purpose was to ascertain which of two different techniques would allow radiographers to obtain the best diagnostic result in the shortest period of time of the cervicothoracic junction.

The respective performances of the two techniques where the advantage of the one method over the other is given by the actual difference and as a percentage (%) were as follow:

ADAPTED SWIMMERS was better in 50% of categories:

Penetration	= 0.2	5%
Contrast & Density	= 0.25	6.25%
C_7/ T_1	= 0.05	1.25%

The SWIMMERS was better in 33.3% of categories:

Rotation	= 0.65	16.25%
Shoulder separation	= 0.3	7.5%

During Hypothesis testing, the p-value for both rows and columns were greater than 0.1. Thus the probability is very high that, reversing the orientation of the arms in the Swimmer's view increases the diagnosis of abnormalities at C_7-T_1 transition.

It was also found that in raising the arm farthest from the film, there was a certain amount of enlargement. The arm acts as a natural filter because the humeri were projected more posterior, it was also more enlarged. It can sometimes be very testing on a radiographer to produce good quality films that are of diagnostic value. Knowing that there is an alternative method to visualising the C_7/T_1 junction could be beneficial not only to radiography, but also to patients.

ADAPTED SWIMMERS should thus not be seen as a substitute for the SWIMMERS, but as a way to help minimize repeat films and radiation exposure where the swimmers is not optimal.

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