Lens Exclusion in Computed Tomography Scans of the Brain —
The Local Practice

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ABSTRACT

Objectives: To review protocols used in Hong Kong public hospitals for computed tomography brain scans, with a view to highlighting potential radiation damage to the lens with particular scanning planes.

Methods: Following a survey of radiological practice in 8 local hospitals, a retrospective study of routine computed tomography brain scanning, with special interest in avoidance of lens exposure, was completed in 2 major regional hospitals. Six hundred patient records were reviewed, along with the scanning protocols used.

Results: The orbitomeatal plane was the predominant reference plane utilised by the majority of public hospitals in this locality, including the 2 hospitals investigated in depth. More than 90% of patients in the study population were found to have either one or both lenses irradiated, despite differences in machines and staff.

Conclusion: A protocol for computed tomography brain scanning, specifying a baseline orientation which excludes the lens, should be established in hospitals to prevent routine lens irradiation.

Key Words: Computed tomography brain, Lens dose, Radiation protection

INTRODUCTION

Since the introduction of computed tomography (CT) into clinical practice, technological developments in the quality and speed of acquisition of images have promoted a continuing growth in CT practice throughout the world. This has had a substantial impact on both patient care and population exposure to medical X-rays.

In a general radiology department, CT of the brain contributes more than half of the workload. Although radiation induced cataract is believed to be associated with exposures of over 5000 mGy, the threshold of low linear-energy-transfer (LET) radiation giving rise to an increasing frequency of ophthalmologically detectable opacities in atomic bomb survivors, has been estimated at approximately 500 to 2000 mGy. Repeated CT scans may exceed this threshold.

In 1982, Lund and Halaburt demonstrated that variation in the plane of scanning with different gantry angulations could affect the radiation dose to the lens. Yeoman et al reported a mean lens dose of 43.44 mGy using an orbitomeatal (OM) baseline, and 5.58 mGy when a supraorbitomeatal (SOM) baseline was used. This corresponds to an 87% dose reduction to the lens, without significantly increasing posterior fossa artifacts.

The aim of this study was to draw radiologists attention to the potential radiation damage to the lens from CT brain studies in different scanning planes, and to review the scanning protocols for CT brain scans in different public hospitals, comparing these with other countries.

MATERIALS AND METHODS

Three choices of baseline plane for CT brain scanning are illustrated in Figures 1, 2, and 3. A survey of radiological practice was conducted in 8 local hospitals to determine the most popular scan plane employed in CT of the brain. A retrospective study was then carried
out in 2 of these hospitals — Tuen Mun Hospital (TMH) and Kwong Wah Hospital (KWH) — in which 300 consecutive patients from each hospital who had undergone CT study of the brain, (excluding those requiring orbital information), were selected for case review. The procedure for CT brain scanning utilised, including gantry angulation, and the number of lenses irradiated during the routine study was recorded.

RESULTS

Eight hospitals in Hong Kong responded to the survey. The most popular baseline plane for routine brain CT scanning was the plane parallel to the OM line. The results of the retrospective study are shown in Table 1. Brain CT scanning commonly used the OM baseline — in 74.7% and 66.1% of studies at KWH and TMH, respectively. At KWH, 18.6% of studies used the SOM baseline, while 6.8% used the Reid baseline. At TMH, the OM baseline was specified in the scanning protocol, and 33.9% of CT brain scans were performed with 0° angulation. This indicates that radiographers and/or radiologists may not be aware of the significance of gantry angulation to both image artifacts and lens irradiation during routine CT brain scanning according to baseline scan plane.

Table 1. Lens irradiation during routine CT brain scanning according to baseline scan plane.

<table>
<thead>
<tr>
<th>Lens irradiation</th>
<th>Orbitomeatal baseline Kwong Wah Hospital</th>
<th>Tuen Mun Hospital</th>
<th>Supraorbitomeatal baseline Kwong Wah Hospital</th>
<th>Tuen Mun Hospital</th>
<th>Other baseline* Kwong Wah Hospital</th>
<th>Tuen Mun Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.1%</td>
<td>3.0%</td>
<td>15.9%</td>
<td>0.0%</td>
<td>0.7%</td>
<td>0.0%</td>
</tr>
<tr>
<td>1</td>
<td>6.1%</td>
<td>4.7%</td>
<td>1.4%</td>
<td>0.0%</td>
<td>0.3%</td>
<td>1.0%</td>
</tr>
<tr>
<td>2</td>
<td>64.5%</td>
<td>58.4%</td>
<td>1.3%</td>
<td>0.0%</td>
<td>5.8%</td>
<td>32.9%</td>
</tr>
<tr>
<td>Total</td>
<td>74.7%</td>
<td>66.1%</td>
<td>18.6%</td>
<td>0.0%</td>
<td>6.8%</td>
<td>33.9%</td>
</tr>
</tbody>
</table>

* Other baseline refers to the Reid baseline for Kwong Wah Hospital and no angulation for Tuen Mun Hospital.
to 280 mGy, \(^8\) while other researchers reported dose ranges of 50 to 150 mGy, \(^9\) and 11.1 to 312.9 mGy. \(^5\) More recently, with the use of the modern CT scanner, lower values of 4.7 to 70.3 mGy have been reported. \(^10\) Different CT techniques may potentially increase the dose substantially, however, and the cumulated dose for repeated examinations could theoretically exceed the threshold for cataract induction in the lens.

There are many factors affecting the radiation dose to the lens during CT scanning of the brain. Some factors relate to the CT scanner itself, such as geometry, collimation and filtration. Others are operator dependent, including X-ray tube potential (kVp), milli-ampere-seconds (mAs), section thickness, gantry angulation, section spacing and overlap.\(^5\) The most effective way of reducing the lens dose appears to be to avoid the orbit from the primary X-ray beam. This view is supported by other researchers.\(^5,6,10\)

Our survey showed that the most popular baseline plane for CT scan of the brain in Hong Kong hospitals, was parallel to the OM line. This finding is similar to the results of an international survey,\(^6\) and probably reflects the historical practice of positioning the chin of the patient downwards to image the posterior fossa in the original water-bath scanners. Rozeik \textit{et al} have demonstrated, however, that the OM baseline is the worst in terms of minimising posterior fossa artifact.\(^12\)

Gantry angulation of 5° to 10° below the Reid baseline was the optimum, and an intermediate result was obtained when the SOM baseline was used. Thus, CT scanning of the brain should be performed either with the beam parallel to, or below the Reid baseline for less posterior fossa artifact, or with the beam parallel to the SOM baseline for a substantial reduction in the radiation dose to the lens.

Reviewing the findings of the retrospective study, the SOM baseline was adopted in 18.6 % of brain CT scans in one hospital, with direct exposure to either one or both lenses largely avoided (KWH: one eye 1.4%; both eyes 1.3% irradiated). The majority of the CT brain studies were scanned with the OM baseline, which included either one or both eyes in the primary beam of the X-rays (KWH: one eye 9.1%, both eyes 70.3%; and TMH: one eye 5.6%, both eyes 91.4%). These findings are similar to the international survey completed by Yeoman \textit{et al} in which only 32% (58 of the total sample of 184 centres) of the CT brain studies routinely angled the gantry away from the eyes.\(^6\)

**CONCLUSION**

A protocol for CT brain scan, with the baseline orientated to exclude the lens from direct irradiation, should be established, since proper gantry angulation markedly reduces the lens dose without degrading the image quality. This practice should be emphasised to both radiographers and radiologists alike. Following this approach, the “as low as reasonably achievable” (ALARA) principle of minimising radiation dose, in this case to the lens, will be achieved during CT brain scanning.

**REFERENCES**