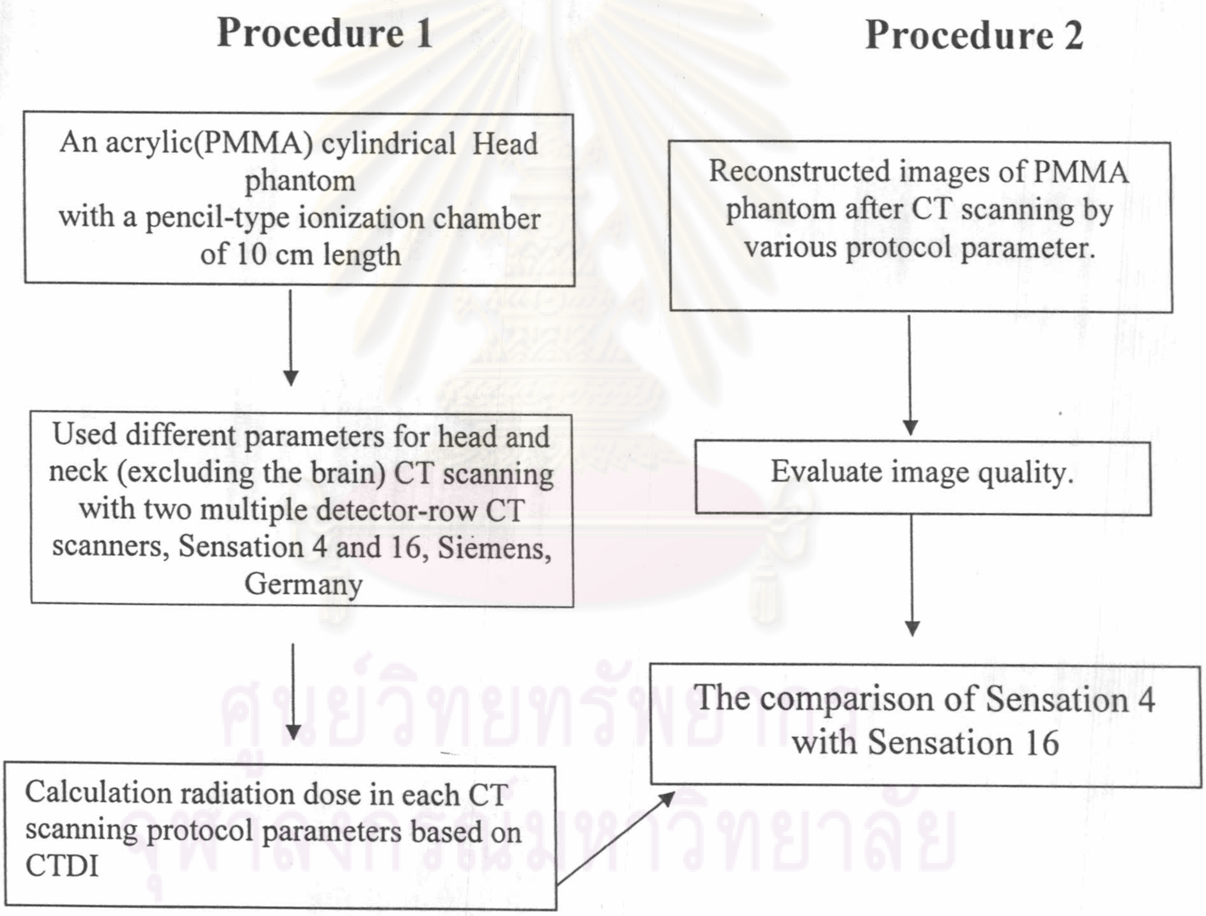
CHAPTER IV

RESEARCH METHODOLOGY

4.1 Research Design

This is a descriptive study research.

4.1.1 Research Design Model



4.2 The Sample

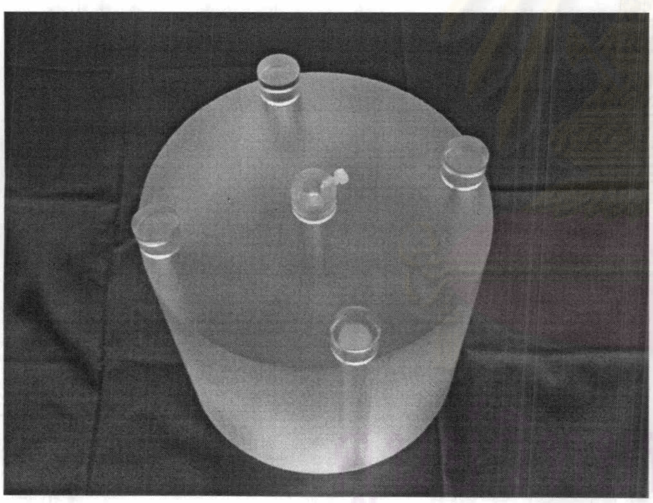
4.2.1 Target population : Patients who were requested for head and/or neck (excluding the brain) CT scanning.

4.2.2 Sample population :

1. A PMMA phantom was used to investigate radiation dose from MDCT for head and neck :

An acrylic (PMMA) cylindrical head phantom of 16 cm diameter, 15 cm length. These cylindrical phantom possess drilled holes in the center and in four symmetrical positions (3, 6, 9, 12 o'clock, each located 1 cm below the surface) to insert a pencil-type ionization chamber of 10 cm length.

This phantom was used to evaluate weighted CT dose index ($CTDI_w$) and average dose (D_{AVE}).



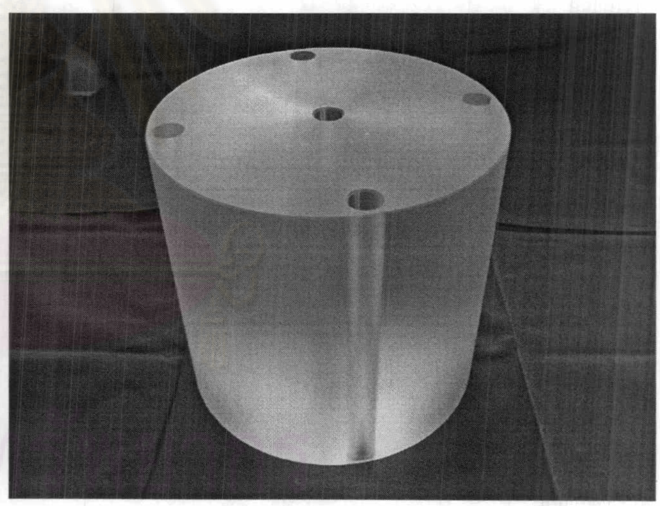


Figure 1 and 2. An acrylic (PMMA) cylindrical head phantom of 16 cm diameter, 15 cm length.

The results of radiation dose from a PMMA head phantom was used to represent radiation dose of patients who were requested for head and neck (excluding the brain and location is from superior aspect of hyoid bone to supraorbitomeatal baseline) CT scanning.

2. The images of PMMA phantom after CT scanning by various protocol parameter. The data of image quality were collected from CT monitor to evaluated image quality.

4.3 Experimental Maneuver

This study would be executed in Department of Radiology at King Chulalongkorn Memorial Hospital, Bangkok using two multi detector-row CT scanners (Sensation 4 and 16, Siemens, Germany). The procedures in this study would be in the following sequence :

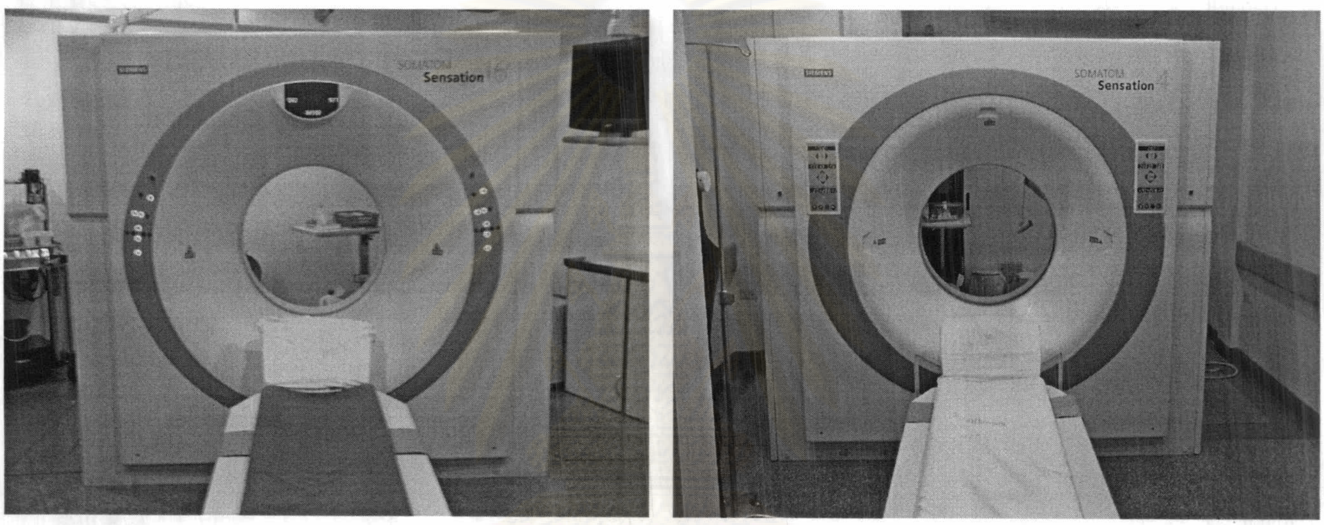


Figure 3 and 4. Two types of CT scanners, on the left side is Siemens Sensation 16 and on the right is Siemens Sensation 4 .

4.3.1. Radiation Dosimetry

Used an acrylic (PMMA) cylindrical head phantom

1. The PMMA cylindrical head phantom was positioned in the center of the gantry, on the head support device so that its length was parallel to the rotational axis of the scanner.

2. The ionization chamber was placed consecutively in each of the five holes provided by the phantom.

3. Scanning was performed on each of the two CT scanners applying the protocols described in the appendix.

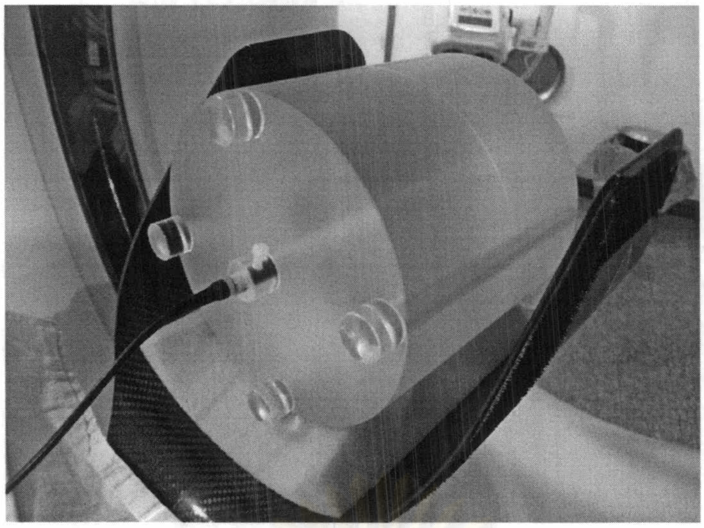


Figure 5. An acrylic (PMMA) cylindrical head phantom with the pencil-type ionization chamber was placed in the gantry of CT scanner.

4. Measurements were performed with one single scan of 360° tube rotation. The number of measurements was 5 for each chamber position. Resulting in 25 measurements for each CT scanner protocol.

5. The ionization chamber is also used to measure the dose free-in-air at the center of rotation.

6. Dose would be calculated as weighted CT dose index ($CTDI_w$) or $CTDI_{vol}$ by using the following formula :

CTDI [8,9]:

$$CTDI_{100} = 1/c \int_{-50mm}^{+50mm} D(x)dx$$

Where c is the norminal section thickness in single slice CT, in multi slice $C = n \cdot d$.

Average dose [8,9]:

$$CTDI_w = 1/3(CTDI_{100})central + 2/3(CTDI_{100})peripheral$$

In order to compare dose values of various protocols with different pitch factors and to be able to estimate patient exposure. It is suggested to used $CTDI_{vol}$ which is define as:

$$CTDI_{vol} = CTDI_w/pitch$$

4.3.2 Reviewed CT images and data collection of image quality

Data collection of image quality after CT scanning by routine protocol parameter.

1. Recalled old images of PMMA phantom showing on CT monitor.

2. The CT image were reconstructed by these protocol :

- Siemens Sensation 16 using :

Image slide width 4.5 mm for thin slice protocol, 9.0 mm for thick slice protocol and kernel H31s in sequential mode.

Image slide width 4.0 mm for thin slice protocol, 8.0 mm for thick slice protocol and kernel H31s in spiral mode.

- Siemens Sensation 4 using :

Image slide width 4.0 mm for thin slice protocol, 8.0 mm for thick slice protocol and kernel H40s in sequential mode.

Image slide width 4.0 mm for thin slice protocol, 8.0 mm for thick slice protocol and kernel H40s in spiral mode.

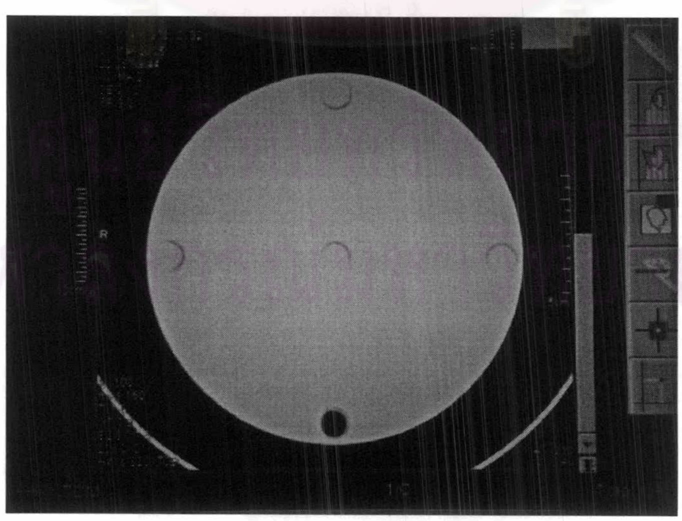


Figure 6. Images of PMMA phantom showing on CT monitor after image reconstruction.

3. Evaluated image quality (to find image noise) by made region of interested (ROI), 1 cm diameter, in the image of phantom and closely to center and peripheral holes of phantom.

4. Read out noise value from the CT monitor.

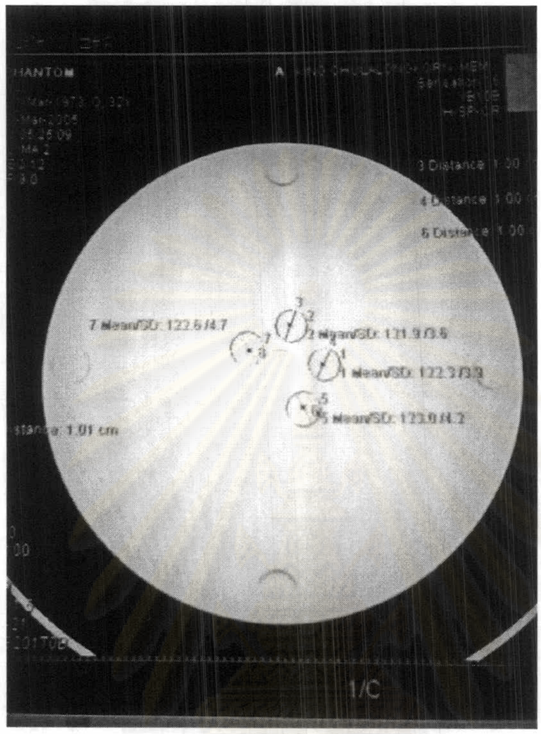


Figure 7. Measurement of image noise from the images of PMMA phantom.

4.4 Measurement

Variables : Independent Variable = Various protocol Parameters

: Dependent Variable = Patient radiation dose

4.4.1 Instruments and Evaluators

Patient radiation dose was measured in mGy using a pencil-type ionization chamber of 10 cm length to absorb radiation energy.

The pencil-type ionization chamber of 10 cm length, type PC4-P (Wellhöfer Dosimetrie, Schwarzenbruck, Germany) was inserted in the cylindrical head phantom and connected with a Capintec digital dosimeter WK 92 (Wellhöfer Dosimetrie, Schwarzenbruck, Germany).

The calculation of radiation dose from cylindrical PMMA CT head phantom was based on determination of the CT dose index (CTDI)[8,9].

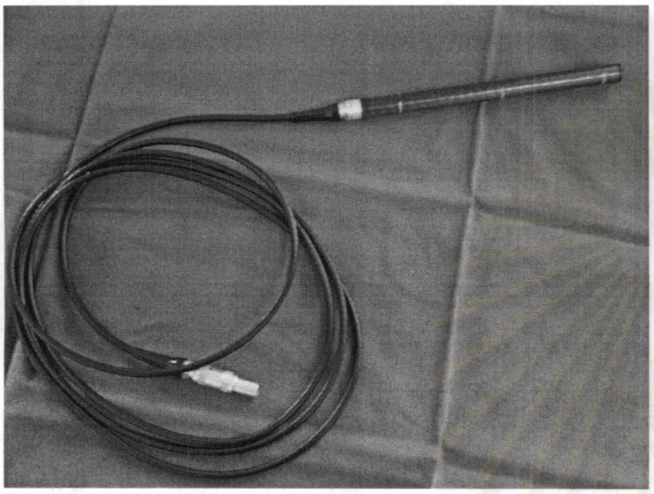


Figure 8 and 9. On the left side is a pencil-type Ionization chamber of 10 cm in length and on the right is the chamber with digital dosimeter.

4.4.2 Outcome to be Measured

1. Main outcome : The primary outcome is radiation dose, measured in mGy by a pencil-type ionization chamber of 10 cm length with digital dosimeter. In cylindrical CT phantom the calculation of average radiation dose was based on CTDI and used in the statistical analysis.

The measurements were performed for each protocol parameter.

2. Secondary outcome : Diagnostic quality of CT images was determined in terms of noise. Noise was evaluated on CT monitor after image reconstruction in each scanning by using the calculation program as :

Noise = S.D.

represents statistical variation of measured density values expressed in Hounsfield units or CT number when scanning a homogeneous object such as water.

4.5 Data Collection

The radiation dose in each protocol parameter was collected by a pencil-type ionization chamber of 10 cm length and PMMA cylindrical head phantom with digital dosimeter.

Noise was evaluated on CT monitor from the images of PMMA head phantom after CT scanning by various protocol parameters.

4.6 Data Analysis

4.6.1 Summarization of Data

The radiation dose and noise were continuous data, the average, SD and range were analyzed.

4.6.2 Data Presentation

The tables, graphs and pictures would be presented.

4.6.3 Hypothesis Testing

This study was done to compare the mean difference of radiation dose for each scanning protocol parameters of 2 types CT scanners. The primary effectiveness end point was radiation dose. The primary effectiveness analysis was based on a protocol parameters of head and neck (excluding the brain) CT examination. A secondary analysis would be performed using diagnostic quality of CT images.

Un-paired *t*-test, SPSS 11.5 for windows was used for statistical analysis, for the comparison of each scanning protocol parameters between Siemens Sensation 4 and Siemens Sensation 16.

4.6.4 Problem from Protocol Deviation

Error in setting CT scanning protocol parameters, i.e, length of scanning, pitch, may be affect the radiation dose from each CT scanner.

4.7 Ethical Consideration

There was **no ethical issues** because all of the procedures would not involve human body or patients.

4.8 Limitations

In this study, we could evaluate quality of CT image only in term of image noise. Other terms of quality of CT image, such as image contrast, could not be evaluated due to lack of equipment for the study.

4.9 Benefits of the Study

In many hospitals with CT scanners, some operators or radiologists lack of awareness of the dose associated with CT. The protocol of head and neck examination that give good or acceptable diagnostic quality of CT image and low radiation dose to patient would be desirable to use for reducing radiation risk.

4.10 Administration and Time Schedule

Ionization Chamber Calibration	February – March 2004
Ionization Chamber and Phantom Preparation	March – April 2004
Data collection	August – October 2004
Data Analysis	November 2004
Thesis Writing	December 2004
Presentation	February 2005