Radiation Risk Management in Low Dose MDCT Screening Programs

16.1 Lung Cancer Screening Including Pulmonary Nodule Management

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16.1.1 Introduction

Lung cancer is the leading cause of cancer-related mortality in the world, with almost one million deaths annually (Parkin et al. 1999). There are more deaths from lung cancer in the United States (US) than from the three next most common cancer-related causes of death (colorectal, breast, and prostate). It was estimated that in 2005, in the US alone, there would be more than 170,000 new cases of lung cancer, with approximately 163,000 related deaths (Jemal et al. 2005). Given these discouraging statistics, it is paramount to try to find the means of decreasing the mortality from this disease.

The reason why lung cancer is so frequently lethal is that most of the patients are diagnosed in the later stages of the disease, when their malignancy has grown beyond cure. By contrast, outcome is significantly improved in patients diagnosed at an earlier, resectable stage, with 5-year survival rates for stage I disease approaching 70% (Williams et al. 1981; Mountain 1986; Mountain et al. 1987; Martini 1990; Shah et al. 1996). Thus, earlier detection of the disease would enhance the chances of a curative resection and thereby reduce lung cancer mortality.

The possibility of producing non-superimposed, cross-sectional images with low-dose computed tomography (CT) places this technique and multidetector CT (MDCT) in strong positions as ideal tools for lung cancer screening. However, the radiation dose delivered to the patient due to baseline CT screening, repeated CT and lung nodule management represents one of the most important issues of this type of screening.
16.1.2
Imaging Techniques Used for Early Lung Cancer Detection

16.1.2.1
Chest Radiography and Sputum Cytology

The first screening test for lung cancer used to be chest radiography. In the 1960s and 1970s there were large randomized trials conducted both in the US and Europe in which volunteers underwent either periodic chest radiography or a simple clinical follow-up as baseline examination (Brett 1969; Fontana et al. 1986). Although these studies found a higher incidence of resectable disease in the screened population, none of them showed a lung cancer mortality reduction with screening.

Large randomized trials conducted mainly in the US over recent decades have addressed the role of chest radiography and sputum cytology examination in screening for lung cancer. The Memorial-Sloan Kettering and John Hopkins University studies compared lung cancer detection rates using annual chest radiography alone (control arm) and annual radiography plus sputum cytology analysis every 4 months (intervention arm) (Flehinger et al. 1984; Frost et al. 1984). The Memorial-Sloan Kettering study enrolled 4,968 men to chest radiography and 5,072 to dual (chest radiography and sputum cytology) screen. There were 144 lung cancers detected in each group. The investigators found no significant difference in stage distribution, resectability, survival or disease-specific mortality between groups and concluded that the addition of sputum cytology examination offered no advantage over annual screening with chest radiography (Melamed et al. 1984). In the Johns Hopkins study, 5,161 men were randomized to chest radiography and 5,226 to dual screening. Screening resulted in the detection of 202 cases of lung cancer in the chest radiography group and 194 cases in the dual screening group (Tockman 1986).

The Mayo Lung Project (Fontana et al. 1984) enrolled over 10,900 subjects. Participants were offered chest radiography and sputum cytology at enrolment. They were then randomly assigned to a close-surveillance group, which underwent 4-monthly chest radiography and sputum cytology, or to a control group, which was advised to have the standard surveillance of yearly chest radiography and sputum analysis. There were no statistically significanct differences in either survival or lung cancer-related mortality between the two groups.

Since those disappointing results, lung cancer screening with chest radiography has been abandoned.

16.1.2.2
Spiral CT and MDCT

16.1.2.2.1
Past Trials

Recent advances in technology have prompted new trials for early detection of lung cancer using spiral CT. The first trials were non-randomized screening studies performed in Japan, using a combination of chest radiography and CT (Kaneko et al. 1996; Sone et al. 1998). The authors demonstrated that low-dose CT was very effective in detecting early-stage lung cancer.

In 1993, the Early Lung Cancer Action Project (ELCAP) was started at Cornell Medical Center (Henschke et al. 1999). In that study, the baseline screening of 1,000 persons (smokers, over the age of 60 years) produced 27 screen-diagnosed lung cancers. Among the discovered lung cancers with low-dose CT, 23 out of 27 were stage I. The authors concluded that low-dose CT may increase the chances of detecting lung cancer at an earlier and potentially more curable stage. The authors demonstrated also that low-dose CT was superior to chest radiography at detecting early lung cancer (Fig. 16.1.1).

The results of other similar studies performed in Europe and in North America (Henschke et al. 1999; Diederich et al. 2002; Sobue et al. 2002; Swensen et al. 2002; Mahadevia et al. 2003; Pastorino et al. 2003; Swensen et al. 2003b; Bastarrika et al. 2005, Gohagan et al. 2005, MacRedmond et al. 2006) have demonstrated that the vast majority of lung cancers detected by screening, both at baseline and annual review, are stage I at diagnosis (Leong et al. 1999). The study by Swensen et al. (2002, 2003b) enrolled 1520 subjects, aged 50 years or more, who underwent annual sputum cytology and also DNA analysis. A total of 26 lung cancers were diagnosed at baseline CT, of which 2 were detected by sputum cytology only. Stage I disease was reported in 19 patients and the lung cancer detection rate was 1.7%. Then 2 years after baseline low-dose CT scanning, a further 588 non-calcified nodules were identified...