Image Guided Percutaneous Radiofrequency Ablation of Lung Tumors

Thesis

Submitted for Partial Fullfillment of M.D. degree
In Radiodiagnosis

By

Ahmed Bahaa El Deen El Serwi

Under Supervision of

Professor Doctor Ahmed Kamal El Dorry
Professor of RadiodiaiMiosis
Ain Shams University

Doctor Sahar Mohamed El Feky
Assistant Professor of Radiodiagnosis
Ain Shams University

Doctor Osama Mohamed A. Hamid Hetta
Assistant Professor Radiodiagnosis
Ain Shams University

Doctor Tarek Hussein Kamel
Assistant Professor of Radiotherapy
Ain Shams University

Ain Shams University
2005

CONTENTS

INTRODUCTION AND AIM OF THE WORK

Most patients with primary and secondary lung malignancies are not surgical candidates ***(Schottenfeld D., 1996).***

The capability of heat to kill cancerous cells has been known for several decades. Tumor cells are more sensitive to heat than is normal tissue, and temperatures as low as 41°C can cause cancer cell death ***(Dupuy et al., 2002).***

During the past two decades, many ablative therapies have been studied as minimally invasive alternatives to surgery. Possible advantages of ablative therapies over surgical resection are their anticipated reduced morbidity and mortality, low cost and capability of being performed on an out patient basis ***(Dupuy et al., 2002).***

Radio frequency ablation works through the deposition of energy into tissue via a percutaneously placed electrode. The energy from the electrical current in the frequency of radio waves omitted by the electrode creates heat in the local tissue, and thus, necrosis, in a controlled fashion.

Radiofrequeucy is at present the most robust technique for the treatment of solid malignancies ***(Dupuy and Goldberg, 2001).***

Intraparenchymal lung tumors seem well suited to radio frequency ablation because the surrounding air in adjacent normal lung parenchyma provides an isolative effect that may concentrate the radiofrequency energy ***(Goldberg et al., 1995).***

Recent developments in radiofrequency thermal ablation have expanded treatment options for certain oncology patients and can be used as an adjunct to conventional surgery, systemic chemotherapy or radiation ***(Wood and Winkler, 2001).***

Aim of the work:

To study the local therapeutic efficacy and complications of percutaneous radiofrequency ablation in the treatment of lung malignancies.

ANATOMY

GROSS ANATOMY :

I-THE LUNGS:

Trachea:

The trachea is a 5 inch long tube having a fibro-elastic wall in which a series of U-shaped bars of hyaline cartilage are embedded keeping the lumen patent. The trachea commences in the neck below the cricoid cartilage of the larynx and ends by dividing into the right and left principal (main) bronchi at the lower border of the fourth thoracic vertebra ***(Snell, 1992)***.

Bronchial tree:

The right principal main bronchus gives off the superior lobar bronchus before entering the hilum of the right lung after which it divides into middle and inferior lobar bronchi. The left principal (main) bronchus divides into a superior and inferior lobar bronchus. Each lobar bronchus then gives rise to the segmental bronchi according to the segmental division of the lungs ***(Snell, 1992)***.

Lungs:

The lungs are soft, spongy and very elastic organs situated on each side of the mediastinum. Each lung is conical in shape and is covered with visceral pleura. It is suspended free in its own pleural cavity, being attached to the mediastinum only by its root. Each lung has a blunt apex projecting into the root of the neck, a concave base that sits on the diaphragm, a convex costal surface, which corresponds to the concave chest wall and a concave mediastinal surface, which is modeled to the pericardium and other mediastinal structures. At about the middle of this surface, the hilum is located, a depression in which the bronchi, vessels, and nerves enter the lung to form the root ***(Snell, 1992)*****.**

Lobes and fissures:

The right lung is slightly larger than the left and is divided by the oblique and horizontal fissure into three lobes (***Figure 1***), the upper, middle, and lower lobes. The left lung is divided only by a similar oblique fissure into two lobes, the upper and the lower lobes. There is no horizontal fissure in the left lung ***(Snell, 1992)***.

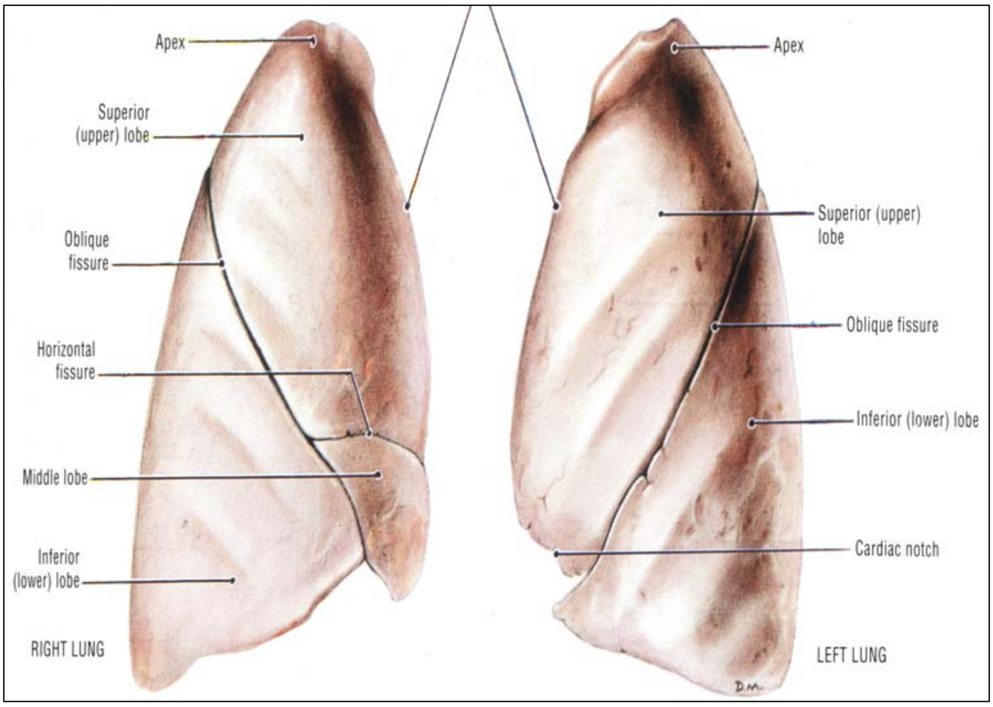

Figure 1. *Illustration of lung lobes* ***(Agur, 1996).***

Blood supply of the lungs:

The bronchi, the connective tissue of the lung and the visceral pleura receive their blood supply from the bronchial arteries, which are branches of the descending aorta. The bronchial veins drain into the azygos and hemiazygos veins. The alveoli receive deoxygenated blood from terminal branches of the pulmonary arteries. Then oxygenated blood drains into tributaries of the pulmonary veins. Two pulmonary veins leave each lung root ***(Snell, 1992)***.

Lymph drainage of the lungs:

Lymph vessels originate in superficial and deep plexuses; they are not present in the alveolar walls. The superficial plexus lies beneath the visceral pleura and drains over the surface of the lung toward the root where they enter the bronchopulmonary nodes. The deep plexus travels along the bronchi and pulmonary vessels toward the root of the lung, passing through pulmonary nodes located within the lung substance; the lymph then enters the bronchopulmonary nodes at the root of the lung. All the lymph from the lung leaves the lung root and drains into the tracheobronchial nodes and then into the bronchomediastinal lymph trunks ***(Sinnatamby, 1999)***.

Nerve supply of the lung:

At the root of each lung is a pulmonary plexus composed of efferent and afferent autonomic nerve fibers. The plexus is formed from branches of the sympathetic trunk and receives parasympathetic fibers from the vagus nerve ***(Snell, 1992)***.

II- THE OVERLYING PLEURA:

The pleural space is bounded by two serosal membranes: the visceral and parietal pleurae. The visceral pleura cover the lungs and forms the interlobar fissures; the parietal pleura cover the mediastinum, diaphragm and inner surface of the thoracic cage ***(Armstrong et al., 1995)*.**

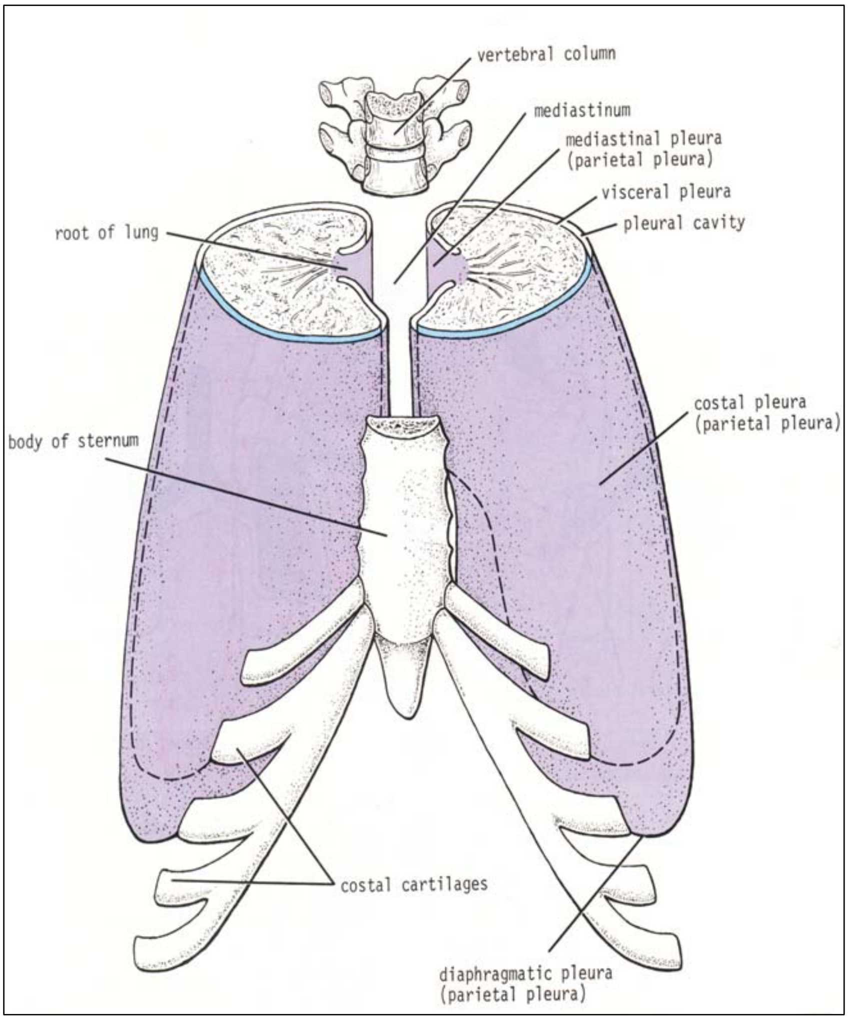

Figure 2. *Pleurae from above and in front* **(*Snell, 1992*).**

The parietal and the visceral layers of the pleura are separated from one another by a small amount of tissue fluid, the pleural fluid, which covers the surfaces of the pleura as a thin film and permits the two layers to move on each other with minimum of friction ***(Muller, 1993)***.

The parietal pleura could further be divided according to the region in which it lies or the surface that it covers (***Figure 2***). ***The cervical pleura*** extend up into the neck, lining the undersurface of the suprapleural membrane. ***The costal pleura*** line the inner surface s of the ribs, the costal cartilages, the intercostal spaces, the sides of the vertebral bodies, and the back of the sternum. ***The diaphragmatic pleura*** cover the thoracic surface of the diaphragm. The ***mediastinal pleura*** cover and form the lateral boundary of the mediastinum. At the root of the lung it is reflected as a cuff around the vessels and bronchi and here becomes continuous with the visceral pleura. During full inspiration the lungs expand and fill the pleural cavities. These are the right and left costophrenic recesses and the right and left costomediastinal recesses which are normal in apposition during quiet respiration separated by the thin pleural fluid ***(Snell, 1992)***.

The endothoracic fascia is a thin layer of loose connective tissue that separates the parietal pleura from the thoracic wall. The suprapleural membrane is a thickening of the endothoracic fascia that covers the dome of the parietal pleura where it projects into the root of the neck ***(Im et al., 1989)***.

Pleural blood supply:

The parietal pleura is supplied by systemic capillary vessels and drains into the right atrium via the azygos, hemiazygos, and internal mammary veins. The visceral pleura is supplied by the pulmonary arterial capillaries and drains mainly into the pulmonary veins ***(Muller, 1993).*** Normal pleural fluid (approximately 10 ml per day) is primarily supplied and drained by parietal pleural vessels ***(Dynes et al., 1992)***.

Pleural lymph drainage:

The lymphatic drainage of the pleural space begins with lymphatic stomata located mainly in the mediastinal, intercostal and diaphragmatic portions of the parietal pleura. These drain into larger lymphatic channels and eventually into the mediastinum, right lymph duct and thoracic duct (***Pistolesi et al, 1989).***

III-THE MEDIASTINUM:

The mediastinum is the space occupying the centre of the thoracic cavity extending superiorly to the thoracic inlet and the root of the neck and inferiorly to the diaphragm. It extends anteriorly to the sternum and posteriorly to the twelve thoracic vertebrae ***(Romanes, 1987)***.

For purposes of description, the mediastinum is divided into superior and inferior mediastinae by the imaginary plane passing from the sternal angle anteriorly to the lower border of the body of the fourth thoracic vertebra posteriorly (***Figure 3***). The inferior mediastinum is further subdivided into the middle mediastinum, which consists of the pericardium and heart; the anterior mediastinum, which is a space between the pericardium and the sternum; and the posterior mediastinum, which lies between the pericardium and the vertebral column ***(Snell, 1992)***.

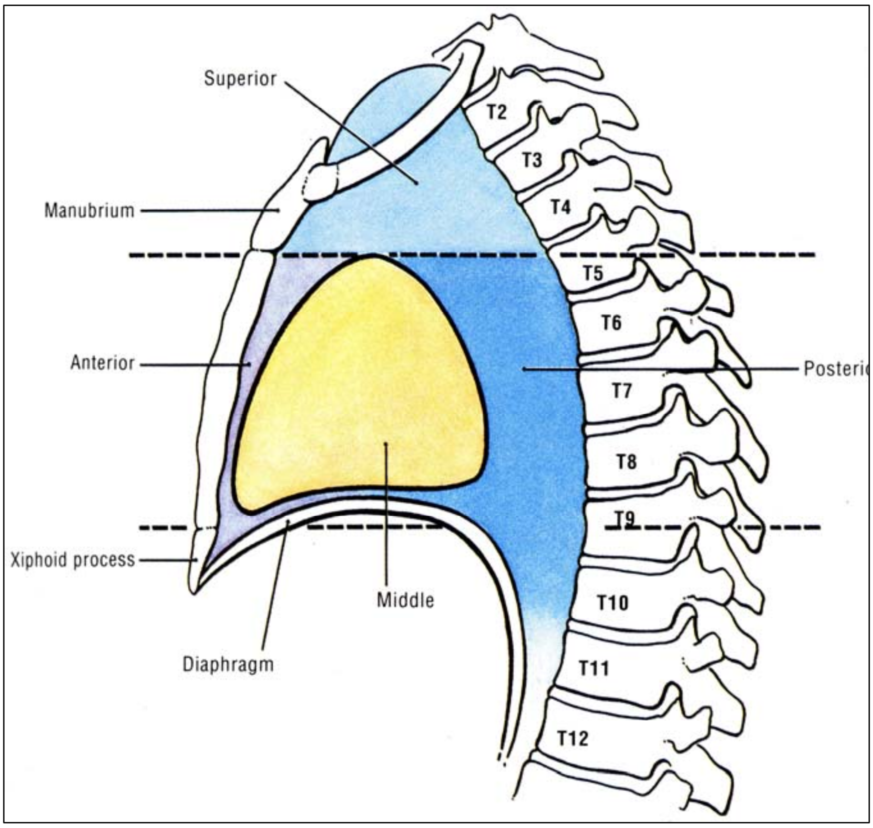

Figure 3. *Illustration of divisions of the mediastinum (**Snell, 1992**).*

CONTENTS OF THE MEDIASTINAL COMPARTMENTS:

A. The superior mediastinum contains the aortic arch, thymus, great vessels, trachea, upper esophagus and the thoracic duct.

B. The anterior mediastinum contains lymph nodes, vessels and fat.

C. The middle mediastinum contains the heart, pericardium, tracheal bifurcation, pulmonary arteries and veins.

D. The posterior mediastinum contains the descending aorta, esophagus, thoracic duct, greater and lesser azygos veins, intercostal veins, vagal nerves and the sympathetic chains ***(LiVolsi, 1994)***.

In addition to the nodes draining the lungs, other nodes are found scattered through the mediastinum. They drain lymph from mediastinal structures and empty into the bronchomediastinal trunks and thoracic duct. Disease and enlargement of these nodes may exert pressure on important neighboring mediastinal structures ***(Sinnatamby, 1999***).

COMPUTED TOMOGRAPHY (CT)

ANATOMY :

Computed tomography superbly demonstrates virtually all anatomic structures in the thorax. This is due in large part to the fact that striking density differences exist between fat, muscle, skeletal structures, and lung parenchyma. Normal fat, which has a low characteristic attenuation value that ranges from -80 to -120 HU, is present in sufficient amounts in most adults to clearly depict most structures of the mediastinum and the chest wall ***(Gutierrez et al., 1998).***

PULMONARY PARENCHYMA

Normal lung architecture and appearance as depicted by CT is reasonably constant, though it will vary somewhat depending on the collimation and the phase of respiration. When images are acquired at full lung capacity (end-inspiratory volume), pulmonary vessels will be maximally displayed, improving recognition of small pathologic pulmonary abnormalities. At resting lung volumes or in expiration, there is considerable crowding of pulmonary vessels, especially in the dependent portion of the lung. This phenomenon can be seen in the lung images from an abdominal CT examination that is performed in expiration. Even with scans done in full inspiration in the supine position, crowding of the vessels posteriorly in the bases and some concomitant dependent atelectasis may be a problem, simulating interstitial disease. By rescanning patients in the prone position, the area is better distended and the confusion overcome ***(Webb et al., 1996)***

The normal range of pulmonary density generally is between -350 to -450 HU, with the differences less on inspiration than expiration. Mean attenuation values in the posterior third of the lungs may be as much as 100 HU greater than the anterior third; the gradient is reduced but not abolished on scans obtained in deep inspiration ***(Webb et al., 1996).***

Normally, vessels will be seen on both thickly and thinly collimated scans virtually all the way to the periphery on the lung images but there is almost always a small subpleural radiolucent zone, 3 to 5 mm in width, devoid of vessels. The bronchi, in distinction, normally are not seen in the outer 2 to 3 cm of the lung parenchyma ***(Gutierrez et al., 1998).***

When the smaller peripheral pulmonary vessels course horizontally, it is generally possible to trace their origin to the major segmental vessels and verify their nature. If, however, a small vessel courses obliquely or in a cephalocaudal direction,