Introduction

Interventional radiology in the thorax is widespread. Although most people associate the practice with nonvascular interventions, such as lung biopsy, in fact, a huge variety of different nonvascular and vascular interventions are performed within thoracic structures (Tables 1, 2), and more, such as radiofrequency ablation of lung tumors, will probably come into the field. In the following, some of the most essential interventions are discussed.

Nonvascular Interventions

In the nonvascular field, CT-guided lung biopsies are the best-known and most frequently performed interventions in this part of the body. Fine-needle aspiration for cytology and miniaturized cutting needles for histology not exceeding 18-20 G are used for this purpose. Automated biopsy guns have several advantages, offering excellent sampling quality and the possibility to perform repeated biopsies with a single access. Fine-needle aspiration is preferred if an object for biopsy is located close to central and vascular structures, in order to avoid major bleeding complications.

Laurent et al. [1] compared the accuracy and complication rate of fine-needle aspiration vs. an automated biopsy device. The study consisted of two consecutive series of 125 (group A) and 98 (group B) biopsies carried out using 20-22 G coaxial fine-needle aspiration (group A) and an automated 19.5 gauge coaxial biopsy device (group B). Groups A and B comprised, respectively, 100 (80%) and 77 (79%) malignant lesions and 25 (20%) and 18 (21%) benign lesions. No significant difference was found between the two series concerning patients, lesions, and procedural variables. For a diagnosis of malignancy, a statistically significant difference in sensitivity was found between the results obtained with the automated biopsy device and those with fine-needle aspiration (82.7% vs. 97.4%, respectively). For a diagnosis of malignancy, the false-negative rate of the biopsy result was significantly higher ($p<0.005$) in group A (17%) than in group B (2.6%). For a specific diagnosis of benignity, no statistically significant difference was found between the two groups (44% vs. 26%), but the automated biopsy device yielded fewer indeterminate cases. There was no difference between the two groups concerning the incidence of pneumothorax, which was 20% in group A and 15% in group B, or that of hemoptysis, which was 2.4% in group A and 4% in group B. The authors concluded that, for the diagnosis of malignancy, automated biopsy devices have a lower rate of false-negative results and a complication rate similar to that of fine-needle aspiration.

Richardson et al. [2] surveyed 5,444 lung biopsies in the UK. Complications included pneumothorax (20.5% of biopsies), pneumothorax requiring chest drain (3.1%), hemoptysis (5.3%), and death (0.15%). The timing of post-procedure chest radiography was variable. In centers that predominantly performed cutting-needle biopsies, the pneumothorax rates were similar to those of centers performing mainly fine-needle biopsies (18.9% vs.
18.3%). There is great variation in practice throughout the UK. Most procedures are carried out on a day-case basis. Small pneumothoraces are common but infrequently require treatment.

Post-biopsy pneumothorax as a rather frequent complication can be treated relatively simply in most cases. In asymptomatic patients we recommend not evacuating the pneumothorax earlier than 4 h after biopsy in order to achieve a durable success. In symptomatic patients or those with drainage failures following a single-needle approach, percutaneously introduced Heimlich valves are recommended.

Minimally invasive thoracoscopic procedures have become increasingly popular and offer a valid alternative if the patient has only a single pulmonary nodule that can be removed for diagnostic as well as therapeutic purposes. In such cases, interventional radiology can be of practical benefit in the procedure by CT-guided hook marking of the nodule, which allows it to be easily identified during thoracoscopy and thus facilitates its removal.

Poretti et al. [3] described their experience with percutaneous CT-guided placement of hook-wires to localize such nodules before video-assisted thoracoscopic (VATS). In their study, 19 patients with newly diagnosed intrapulmonary nodules underwent CT-guided hook-wire (X-Reidy set) localization. Subsequently, the patients underwent VATS resection of their lesions, which required a mean time of 30 min (range 10-48 min). In all patients, resection of the nodules was successful. Eight patients developed an asymptomatic pneumothorax. In four patients, in whom the tumor was hit directly by the needle, local bleeding occurred. One patient experienced hemoptysis. However, dislocation of the hook-wire system did not occur in any of the patients.

Other nonvascular interventions include abscess drainage from the lung, the pleura, and the mediastinum (Fig. 1).

Breast Biopsy

Breast biopsy is of increasing importance in daily practice, as in European countries more and more lesions detected during screening programs are either indicative of malignancy or at least suspicious and not clearly classifiable. A growing number of patients also request a definitive diagnosis even for an otherwise benign-appearing lesion.

Breast biopsy may be performed by ultrasound or MR guidance, or under stereotactic mammographic guidance. For lesions that are detectable by ultrasound, ultrasound guidance is a quick and relatively easy approach that allows online monitoring of the biopsy procedure. Microcalcifications are best detected and biopsied under mammographic guidance. In addition to core biopsy using 14 G needles, vacuum aspiration biopsy using a 10 G needle is recommendable, as it allows removal of larger portions of tissue which makes the procedure safer and the obtained sample more representative. Soft-tissue structures that are detectable by mammography but have no clear correlation in ultrasound should be examined by mammographic core biopsy. MR-positive lesions that have no clear correlations in other modalities should be evaluated by MR-guided core biopsy or placement of a marker under MR guidance followed by surgical resection.

Vascular Interventions

Vascular interventions can be divided between arterial and venous interventions (Table 2).

In the former, balloon angioplasty of supra-aortic arteries such as the subclavian artery, implantation of thoracic endografts, and embolization of bronchial arteries should be mentioned. Relatively rarely performed are transarterial techniques for tumor treatment, such as chemoperfusion of the lateral thoracic, mammary, and bronchial arteries in order to treat bronchial or breast cancer.

Vascular interventions involving the pulmonary artery include occlusion of arteriopulmonary fistulas, particularly in patients with Rendu-Osler-Weber syndrome. Local thrombolysis or thrombodestruction of pulmonary emboli is an intervention used relatively rarely but it offers a promising alternative in emergency cases involving pulmonary embolism.

In the venous area, central venous stents are used to treat malignancies and, in dialysis patients, to recanalize central venous stenoses in order to allow successful drainage. In addition, stents are employed in the placement and maintenance of central venous catheters, fibrin-sheath stripping, and the removal of foreign bodies.

Not all these interventions can be discussed here in depth, but embolization of the bronchial arteries and treatment of malignant venous stenoses should be emphasized, since neither is well-known but either one could be helpful in treating patients with acute symptoms.