MDCT DIAGNOSTIC EVALUATION OF TRACHEAL AND PRIMARY BRONCHIAL PATHOLOGY

SILVIA REGALBUTO
University of Messina - Faculty of Medicine and Surgery, Department of Radiologic Sciences

SUMMARY

The intent of this study is to examine the diagnostic contribution of MDCT and its role, in comparison with traditional endoscopy, in the evaluation of pathologies which obstruct the central respiratory tract, thanks to virtual bronchoscopy, a non-invasive, reproducible and objective technique compared to flexible bronchoscopy. The technique could represent a valuable alternative for patients of advanced age or those presenting pathologies which obstruct the central respiratory tract, or also in cases in which traditional bronchoscopy doesn’t provide sufficient information, e.g. lesions totally obstructing one bronchus, or copious bleeding due to attempted biopsy. Results of some cases in which the technique was applied are presented, compared with the traditional methodologies.

Key words: Virtual bronchoscopy, bronchi, stenosis

RIASSUNTO

Lo scopo del presente lavoro, consiste nel valutare l’apporto diagnostico della MSCT e il suo ruolo rispetto all’endoscopia tradizionale nella valutazione delle patologie ostruenti le vie respiratorie centrali, grazie alla broncoscopia virtuale, tecnica non invasiva, riproducibile e oggettiva rispetto all’endoscopia con broncoscopio flessibile. Tale tecnica potrebbe rappresentare una valida alternativa per pazienti in età avanzata o che presentino patologie ostruenti le vie respiratorie centrali o nei casi in cui la broncoscopia tradizionale non dà informazioni sufficienti a causa ad es. di lesioni che ostruiscono completamente un bronco o per copiosi sanguinamenti dovuti a tentativo di biopsia. Sono presentati i risultati di alcuni casi di applicazione di questa tecnica a confronto con le tecniche tradizionali.

Parole chiave: Broncoscopia virtuale, bronchi e stenosi

Introduction

Virtual bronchoscopy is a three-dimensional (3D) Computed Tomography (CT) technique which produces high definition images of the tracheobronchial tree, and endobronchial images that simulate traditional bronchoscopy results. Although the technique was described in the mid-nineties, it has been generating a new interest due to computer enhancements in hardware and software and improvement in MDCT technology. Pathologies which obstruct central respiratory tract, both benign and malignant, represent an important cause of mortality and morbidity(1,2). The main causes of airways local impairment are: intraluminal neoplasias, extrinsic compressions, tracheomalacia, aberrant granulomatous tissue and fibrosis. Patients with these types of lesions, which concern proximal respiratory tract, in the beginning often present partial or total bronchial obstruction(3). In these patients a non invasive, reproducible and objective methodology may be useful, especially through high definition images of the tracheobronchial tree and endobronchial images which simulate the traditional bronchoscopy results(2,3). Patients with chest pathologies, producing airways stenosis, are submitted to standard diagnostic procedures which include CT and flexible bronchoscopy(2-4). Although these are extremely precise and reliable methodologies, both present technical limits which could cause an inaccurate characterization of the respiratory pathology(3). Multi-detector spiral CT permitted the acquisition of thin-layer axial sections of entire corporeal volumes during a single brief apnoea(5-7), eliminating respiratory artifacts(8) also in patients with low collaborative capacity(9). The possibility to have multi-planar and tridimensional images consented to show focal airways stenosis and to localize the lesion in endobronchial, peribronchial and submucosal site(10,11). Furthermore, 3D techniques allowed virtual bronchoscopy, a type of reconstruction which, ex-ploiting the natural contrast between the endoluminal aerial content and the surrounding tissue(9,12), permits to “navigate” inside the tracheobronchial tree(13), reproducing the same endoluminal perspective as the real endoscopic exam(13,14). Axial
images allow the identification of known or suspected airways pathology, and the evaluation of possible consensual mediastinic and/or pulmonary pathologies. MPR reconstructions consent to ascertain the presence of a stenotic lesion and if it involves the airways or not, to evaluate its side, its distance from the carina and its craniocaudal extension, to define its level, its relation with the surrounding anatomic structures and finally to establish the bronchial patency.

Virtual bronchoscopy is not an operator dependent technique\cite{14}, and several studies in the literature have shown a 63-100% sensitivity for central stenosis location, and a 61-99% specificity\cite{3,8,12}; nonetheless, at present virtual investigation can’t replace the conventional one, since it is not free from limits. An intrinsic limit is the inability to make biotic removals for histocytologic analysis of tissue\cite{1,3,8,15}, to make a chromatic distinction between normal mucosa and pathologic tissue\cite{1,3,8}, and even to assess its consistency\cite{10,16}. At present real endoscopy remains the gold standard exam in order to identify and typify even small-sized airways lesions\cite{10}. At times bronchoscopy doesn’t provide sufficient information, since the lesion completely obstructs one bronchus, and therefore downstream branches of obstruction itself can’t be evaluate, because of a copious bleeding due to an attempted biopsy, or because some coexisting conditions (advanced age, tacheomalacia, etc.) advise against it if not strictly necessary\cite{10}. In addition, conventional endoscopy is an uncomfortable technique, poorly tolerated by patients, and for this reason local sedation is required\cite{17,9}.

**Case study**

**Typical primitive tracheobronchial pathologies**

_**Tracheal pathology is divided into:**_
- a) Focal reduction in tracheal caliber;
- b) Diffuse reduction in tracheal caliber;
- c) Diffuse increase in tracheal caliber.

**Focal reduction in tracheal caliber**

Most of tracheal stenosis are caused by a lesion following an endotracheal tube or a tracheotomy. After prolonged endotracheal intubation, 1% of patients develop fibrotic stenosis. Significant stenosis may be usually found in the stomal site or where the inflatable cuff is inserted.

Thermal, post-infectious and idiopathic subglottic lesions are little common causes of benign focal stenosis. Chest radiography is generally the first imaging examination carried out on patients with suspected tracheal anomalies. However, tracheal analysis may be difficult to carry out due to superimposition of other mediastinal structures.

**Iatrogenic laceration due to orotracheal intubation**

Patient submitted to prolonged orotracheal intubation.

**Fig. 1:** CT shows considerable subcutaneous emphysema, presence of pneumomediastinum and wide iatrogenic laceration.

**Fig. 2:** The wide iatrogenic laceration is clearly shown through virtual endoscopy.

**Fig. 3:** And through the traditional endoscopy.

**Fig. 4:** CT for general check-up carried out after 48 hours shows collapse of the iatrogenic laceration.

**Fig. 5:** The report is well visible also through the less invasive virtual endoscopy.

**Fig. 6:** After 7 days standard bronchoscopy for general check-up is carried out, showing the presence of reparative granulation tissue.
Spiral volumetric CT and, more recently, MDCT permitted to improve multiplanar and 3D reconstructions of the bronchial tree (including endoluminal virtual bronchoscopy), overcoming axial images limitations, like the ability to locate ring stenosis, to accurately estimate longitudinal extension of the disease, and to offer complete outline of the complex anatomical relations.

Benign tracheal neoplasias:
In adults, benign tracheal neoplasias (papillomas, mye-lin sheath tumors, haemangiomas, chondromas, pleomorphis adenomas) are little common, representing less than 10% of tracheal neoplasias. Although benign lesions are often smooth, well circumscribed and less than 2 cm in diameter, also malignant lesions may look like this on CT images\(^2\(^{23}\). In fact CT role is not to afford a specific histologic diagnosis, but to show tumor extension especially out of the tracheal lumen.

**Benign Neoplasias**

![Fig. 7: CT image shows the presence of endotracheal peduncular papilloma.](image1)

![Fig. 8: Visualization through traditional endoscopy.](image2)

![Fig. 9: Visualization through virtual endoscopy can be compared to the traditional one, and it accurately highlights the neoplasm peduncle.](image3)

**Malignant tracheal neoplasias:**
Most of primary malignant tracheal tumors arise in adults. The most common are squeamish cell carcinoma and adenoid cystic carcinoma, which represent more than 80% of malignant lesions.

Other less frequent tumors are adenocarcinoma, microcytoma, mucoepidermoid carcinoma, carcinoid tumor, sarcoma.

On CT a smooth or irregular intraluminal mass may be observed, with eccentric thickening of the tracheal wall and asymmetric luminal thinning.

Extratracheal extension of lesions into mediastinal fat is common.

Bronchoscopy allows to obtain histologic diagnosis and identification of mucosal and intraluminal components, but it is often unable to determine real extension in mass. Tumors may have an extraluminal component, may involve adjacent mediastinal structures and metastatize locally and at a distance. Accurate analysis of longitudinal tumor extent is important to evaluate its surgical resection. This is true especially for adenoid cystic carcinoma, which has the tendency to grow under the mucosa without producing a distinct mass, and potentially simulating a diffuse airways pathology. Spiral CT with 3D image reconstruction algorithms is able to reduce this problem. Direct tumor invasion may be diagnosed with certainty only in presence of an irregular thickening of the tracheal wall or an intraluminal mass.

**MDCT possibilities are:**
- Standard analysis on axial, coronal or sagittal plane;
- MPR reconstructions;
- VR reconstruction;
- Virtual endoscopy.

The last two possibilities permit to display the examined organs in space, and they are particularly recommended in the study of typical tracheobronchial pathologies. Elements of examination of tracheal steno-sis, especially in the primary tract (laryngeal stenosis), are:
- Morphology;
- Stenosis extent;
- Craniocaudal extent;
- Ring thickness;
- Peritracheal anatomic condition

**Diffuse reduction in tracheal caliber**
It was associated with several disorders including:
- Pathologies with average parietal thickness like tracheomalacia and “sabre-sheath” trachea;
- Pathologies connected with diffuse or multifocal tracheal wall thickening like recidivant polychondritis, amyloidosis, tracheopatia osteochondroplastica, Wegener’s granulomatosis.

*In the case of tracheomalacia,* dynamic multiple-plane analysis of airways caliber through spiral CT allows accurate examination of the airways collapse during exhalation. Images reconstruction also permits to have a complete picture of the longitudinal extension of the disease.
In the case of “sabre-sheath” trachea, in CT images, tracheal cartilages appear densely calcified and present a thin anterior arch. Scans obtained during forced exhalation may show an interior collapse of the lateral tracheal wall.

In the case of recidivant polychondritis, CT is of primary importance to establish respiratory tract involvement, since it is difficult to obtain bioptic samples through bronchoscopy, which may find impassable obstacles and even cause inflammatory exacerbations. On CT a diffuse and smooth tracheal wall thickening can be observed, with deformity and thinning of tracheal lumen. Chronic inflammation of cartilage and its destruction may produce secondary tracheomalacia.

In the case of tracheobronchial amyloidosis, the most common form, characterized by multiple submucosal and muscular deposits of amyloid plaques and nodules which may cause wall atrophy, in 14% of patients amyloid material is a solitary deposit that may simulate an endobronchial neoplasia. CT images may show a focal or diffuse airway thinning, with tracheal or bronchial wall thickening.

In the case of tracheapatia osteochondroplastica, an idiopathic and asymptomatic disease in most of the patients, characterized by formation of multiple cartilaginous, osseous or mixed nodules in the tracheal and primary bronchial submucosa, CT allows to define multiple, often calcified nodules, which protrude into the airway lumen and may cause irregular narrowing of trachea and central bronchi.

In the case of Wegener’s granulomatosis, the most frequent CT finding is a nodule or an eccentric parietal soft-tissue mass, associated with alteration of tracheal rings, which may display calcifications or irregularities caused by erosion.

In sarcoidosis, a multisystem granulomatous disease of unknown aetiology, CT allows identification of granulomatous formations, which appear as areas of mucosal thickening, and possible mediastinal masses.

In squamocellular papilloma of the respiratory tract, on CT tracheal papillomas may appear as small or large intraluminal nodules.

**Diffuse increase in tracheal caliber**

In tracheobronchomegaly (or Mounier-Kuhn syndrome), a rare disorder characterized by enlargement of trachea and major bronchi, as a result of atrophy of elastic and muscular tissue also affecting cartilaginous and membranous portions of trachea, CT diagnosis is carried out when tracheal transverse diameter is more than 3 cm and when right and left main bronchial diameters are respectively 2.4 and 2.3 cm.

**Tracheal and main bronchial diverticula** represent a rare and infrequently diagnosed pathology, which has seldom been investigated in its semielogic aspects and in its etiopathogenesis, represented by single or multiple invaginations of the tracheal wall. Two different types of diverticula exist, congenital or acquired, with different histology and location. CT proved to be an effective method for evaluating their presence, number and size. In almost all cases, by demonstrating the narrow communication through the tracheal wall, CT enabled anatomical characterisation and differentiation of tracheal diverticula from laryngocele or oesophageal diverticula.

**Bronchial atresia** frequently involves the left upper lobe apical segment; it may be associated with a bronchogenic cyst. CT shows the atresic lobar bronchus, whereas more distal parts appear normal in caliber. Mucous secretions produced by bronchial structures downstream of the atresic portion can’t go beyond bronchial stenotic portion, therefore mucous plugs and mucocele may develop. CT can identify mucocele as a perihilar branched structure, and can document also hyperdistension of the pathologic segment.

**Foreign bodies aspirated into tracheobronchial tree**: aspiration of foreign bodies may represent a condition made worse by immediate risk of acute deadly asphyxia, if not rapidly and therapeutically resolved, or it may manifest itself with respiratory insufficiency symptoms, and cause also long-term complications. In recent years radiology literature has underlined the diagnostic contribution of high resolution CT, virtual bronchoscopy with multi-layer CT and fiberoptic bronchoscopy in evaluating patients with suspected aspiration of foreign bodies into tracheobronchial tree, with consequent reduction of the role traditionally attributed to chest radiography examination. In conclusion chest radiography remains the first imaging modality for patients with clinically suspected tracheobronchial aspiration of a foreign body. Nevertheless, in case of negative chest radiography and a high suspicion of foreignbody aspiration, chest MDCT - possibly integrated with virtual bronchoscopy - should be considered, in order to avoid unnecessary bronchoscopy.
Foreign bodies ingestion is a frequent event in children, whereas it is rare in adults, in which it is associated with particular pathologic conditions (mental retardation, convulsive crisis, Parkinson’s disease, etc.)

Acquired airways alterations
Tracheal non-neoplastic stenosis: reductions in caliber may involve the entire trachea or parts of it, and may be caused by a systemic pulmonary pathology, or a pathologic process confined to the trachea itself. CT is able to distinguish between intrinsic and extrinsic tracheal lesion (compressions), and to exclude a malignant process. “Sabre-sheath” trachea is typical of chronic obstructive pulmonary diseases and it is caused by an elevated transmural thoracic pressure. CT feature is often nonspecific, and if it is associated with a parietal thickening, an histological sample is necessary to make a diagnosis. In fact, CT can identify the segment of interest, define stenosis level and visualize possible bronchial segments involved.

Patient operated for thyroidectomy with reconstruction of the first portion of tracheal wall, and placement of a Gore-Tex patch.

Tracheobronchial tumors
Carcinoid: it is classified among neuroendocrine tumors, and represents less than 4% of all bronchial neoplasias. It is a locally invasive tumor and it tends to metastatize into locoregional lymph nodes, skeletal system and liver. In about 90% of cases it is an endobronchial tumor and involves central airways, determining their obstruction. On CT, endobronchial form appears as a nodule usually localized by the bronchial bifurcations. It frequently determines airways obstruction and can be associated with entrapment of air, bronchiectasis, mucus stagnation or pneumonia. Bronchial carcinoma: this tumor has the highest death rate and represents the most frequent airways neoplasia. Smoking habit is the predisposing risk factor, which increases ten times its incidence, whereas passive smoking doubles its risk. CT has a 50-70% accuracy in evaluating local extension of bronchial carcinoma; in fact, the methodology is unable to precisely identify a submucosal involvement in neoplasia. CT is useful not only for selecting patients subjected to further invasive procedures (mediastinoscopy, mediastinotomy, transbronchial biopsy) in order to stage lymph nodes, but also for choosing the most appropriate procedure according to the enlarged lymph nodal site examined. Despite the well-known CT limit in detecting metastasis in normal sized lymph nodes, the presence of lymph nodal enlargement is sufficient to avoid indepth examinations and to send the patient directly to toracotomy. It is appropriate to execute a biopsy on the lymphadenomegalies documented on CT to avoid an overestimation of lymphnodal metastasis.

This technique facilitates automatic detection and morphological and volumetric nodule analysis. of the inferior lobe. Foreign body detected, which generated the occlusion, was a meat bolus.
Conclusions

Modern diagnostic imaging, and MDCT in particular, allows the individuation of central airways stenosis with more accuracy than the conventional one, especially in case of widespread and not much tight stenosis; it can provide a precise diagnosis or at least significantly reduce the range of differential diagnosis, and it can integrate fiberoptic bronchoscopy evaluation. Nevertheless, traditional bronchoscopy maintains the unquestionable diagnostic and therapeutic value which justifies its relative invasivity and risk of complications. On account of this, we can consider the two techniques not as opposite, but complementary each other; in fact, integrating their information, they can provide an accurate preoperative characterization of tracheobronchial pathologies, which can then increase their therapeutic effectiveness. Therefore virtual bronchoscopy can’t be considered as an alternative to the traditional one, but a preliminary technique to shorten the following endoscopic procedure. Virtual bronchoscopy may be also advised both as an effective instrument to plan the most appropriate postoperative therapeutic treatment, and as a follow-up care to evaluate the response to treatment for oncological patients and those with serious stenotic pathologies and highly compromised clinical conditions.

Bibliografia


Request reprints from
Dott.ssa SILVIA REGALBUTO
Via Renato Randazzo n.10
96100 Siracusa
(Italy)