Computer-aided detection (CAD) of lung metastases prior to pulmonary metastasectomy - results of a retrospective pilot study

Poster No.: C-1805
Congress: ECR 2011
Type: Scientific Exhibit
Authors: C. Meybaum, A. Schramm, G. Leschber, J. Merk, D. Wormanns; Berlin/DE
Keywords: Metastases, CAD, CT, Oncology, Lung
DOI: 10.1594/ecr2011/C-1805

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Purpose

Surgical resection is considered an option for treatment of metachronous lung metastases in specific malignant tumour entities, for instance in colorectal cancer. Usually the complete removal of all tumour manifestations is desired. This requires the highest possible sensitivity for detection of metastatic lesions within the lungs. Until now the manual palpation of the deflated lung is the standard of reference with the highest sensitivity [1-3].

With the advances of minimal invasive surgery, especially video- assisted thoracoscopy (VATS) a less invasive approach for lung resection has become available. The biggest advantage of VATS for the patient is the much less traumatic nature of the procedure. However, the missing possibility to palpate the operated lung for exclusion of additional metastases is a major drawback of the minimal invasive approach. Therefore, its value in metastasectomy is yet to be defined. One important prerequisite for wider use of VATS in metastasectomy is a reliable preoperative localisation of all metastases. Especially, VATS could be an option for solitary pulmonary metastases if CT would be able to reliably exclude further metastases.

With modern multidetector-row CT (MDCT) scanners with sub-millimeter collimation the depiction of soft-tissue density metastatic nodules within the lung parenchyma is no longer a technical problem like it has been with 5 mm or even 10 mm slice thickness which contributed to the surgeon’s opinion that CT is an unreliable method for detection of lung metastases. Instead, the radiologist’s ability to detect all tiny lung nodules in hundreds of thin CT slices became the bottleneck of the diagnostic process. In studies the sensitivity of a single radiologist for detection of small lung nodules in MDCT scans was in the range of 50 to 70% [4-5]. Computer-aided detection software is known to increase radiologists’ sensitivity [6].
Hence, **we hypothesized** that the utilisation of CAD in the diagnostic process would result in a reliable detection of all lung metastases on CT scans thus allowing for using minimal invasive VATS for metastasectomy without an increased risk of residual metastatic disease due to a detection failure. In this retrospective pilot study we evaluated the effectiveness of thin-slice MDCT in combination with CAD to predict the number and location of lung metastases. For that purpose all CT findings with CAD were correlated with the surgical and histopathological findings in order to determine the amount of metastatic lesions found only by manual palpation during surgery and were not detected prior to surgery by MDCT with CAD.
Methods and Materials

Study design

Candidate patients were included in this retrospective study if the following criteria were met:

- resection of lung metastases was performed during the time range from September 2009 until April 2010, and
- histopathological results are available for all resected lung nodules, and
- a chest CT scan not older than three months (preferably not older than four weeks) prior to surgery was performed and is stored on the PACS system, and
- the CT scan was appropriate to perform a computer-aided- detection (CAD) analysis (slice thickness ≤ 2 mm; reconstruction increment ≤ 1 mm), and
- CAD analysis was performed prior to surgery, and the results were stored on the PACS system

Study population

Data retrieval from the hospital information system yielded 81 cases in which pulmonary metastasectomy was performed from September 2009 to April 2010. Of these, 47 cases met all inclusion criteria and were enrolled in the study. These 47 surgical procedures were performed in 31 distinct patients. In 16 patients one surgical procedure, and in 15 patients two surgical procedures were performed (thoracotomy with sequential resection of lung metastases in both lungs). No synchronous bilateral metastasectomy has been performed. The study population consisted of 19 male and 12 female patients with an average age of 58 ± 14 years (range 13 to 82 years).

CT scan and CAD scheme

All patients either received a chest CT scan with a Siemens Somatom Emotion 16 (2007) in our institution or had an at least adequate external CT available. Scan parameters were set to 110 kVp tube voltage, 70 mAs effective tube current, 2 mm slice thickness, 1 mm reconstruction increment. The reconstructed CT data were transferred to the CAD server and processed using Median LMS Lung version 5.4 (Median Technologies, Valbonne, France). In all cases the CT scans processed by LMS Lung were reviewed by a board certified radiologist with more than 10
years professional experience. CT scans were thoroughly reviewed first using the original axial images and in a second reading procedure using 5 to 10 mm thick sliding thin-slab maximum intensity projections (SPS-MIP). After completing the reading task the radiologist took "snapshots" of all lesions (sorted by right vs. left lung). These "snapshots" were sent to the PACS and were available to the surgeon during metastasectomy in the operating room (figure 1).

Surgical and histopathological proof

The surgeon tried to locate all lesions marked by the radiologist with the help of the CAD system. If he palpates a lesion in the location of the radiological finding then it was resected. If no lesion was palpable the surgeon tried to resect the lesion by obtaining a specimen from the suspicious lung region. All resected lesions were labelled alphabetically "lesion A", "lesion B" etc. The pathologist referred to these labels in his report and reported if the resected lesion was metastatic or not. The histopathological report was the standard of reference in this retrospective study.

Matching of surgical findings as described by the surgeon in the operation report were matched with the CT findings using all available sources of information, in particular the operation report which mentioned the correlation with CT findings in most cases, the discharge summary with information on the segmental localisation and benign or malignant nature of the different lesions, and the original histopathological report if necessary. Radiologist and surgeon often located the same finding in different segments; the most reliable location information was the lung lobe in which the finding was located. This could be easily and reliably determined by the surgeon, and location of a nodule in a specific lung lobe was the most fundamental information used for retrospective matching of radiological and surgical findings. If necessary and available further follow-up CT scans were used to determine the sites of resection in doubtful cases (figure 2).
Fig.: 2. example for using a postoperative CT scan to determine the site of resected pulmonary lesion in a doubtful case (left: CT scan prior to metastasectomy, right: postoperative CT scan with scar due to wedge resection and clip-marked region)

References: Department of Radiology, Evangelische Lungenklinik Berlin - Berlin/DE
Results

Overview

A total of 235 lesions were surgically resected. Of these, 144 (61.3%) have been reported by the radiologist with the CAD system (figure 3). Of all 235 lesions, 85 (36.2%) were diagnosed as metastases in the histopathological report. Five of these metastases were reported to be pleural or subpleural by the surgeon or the pathologist. Radiologists reported 78 of these metastases, resulting in a sensitivity of 91.8%. Taking into account only intrapulmonary (not pleural or subpleural) lesions sensitivity was 96.2% (77 of 80 intrapulmonary metastases).

Fig.: 3. Venn diagram of radiologically detected and surgically resected pulmonary lesions

References: Department of Radiology, Evangelische Lungenklinik Berlin - Berlin/DE

False negative findings at CT

Seven metastases were missed by the reporting radiologist. Of these, four were reported to be pleural or subpleural by the surgeon or the pathologist and were not visible at CT even in retrospect. The size of these lesions was 2 to 4 mm. Two other lesions (figure 4) were retrospectively obvious findings at CT, and both radiologist
and CAD system had overlooked these lesions; size was 8 mm in one case and 30 mm (as reported in the histopathological report) in the other case. The large second lesion was located adjacent to a vessel in the central lung region and had a long oval shape so it was probably misinterpreted as a vascular structure at the unenhanced CT scan.

Fig.: 4. The two pulmonary lesions which were overlooked by radiologist and CAD

References: Department of Radiology, Evangelische Lungenklinik Berlin - Berlin/DE

The seventh missed lesion was reported to be centrally located by the surgeon and had a diameter of 13 mm in the histopathological report. It was not possible to identify this lesion even in retrospect at the unenhanced CT scan, probably due to an adjacent large pulmonary vessel which could not be discriminated from the lesion.

Performance of the CAD system

The CAD system alone detected 100 lesions, 51 of them proved to be metastatic. The sensitivity was 70.0% (100 / 143) for all lesions detected by the radiologist and 42.6% (100 / 235) for all surgically resected lung lesions. Sensitivity was 60.0% (51 / 85) for histologically proven lung metastases. Taking into account only intrapulmonary metastases (omitting all lesions reported to be pleural / subpleural by the surgeon or the pathologist) yielded a sensitivity of 62.5% (50 / 80). The false positive rate was on average 4.0 per CT scan (ranging from 0 to 13, median 4.0).
The performance of a CAD system is highly dependent on the size of the lesions to be detected (table 1). Therefore an analysis of the CAD performance depending on the size class of all metastases was performed whereas the lesions were distributed to the size class 1 (≤5 mm), class 2 (6 to 10 mm) and class 3 (>10 mm). Sensitivity was 77.8% (14 / 18) in class 1, 80.0% (16 / 20) in class 2 and 51.3% (20 / 39) in class 3. The combined sensitivity for lung metastases ≥10 mm was 78.9% (30 / 38).

<table>
<thead>
<tr>
<th>Size class</th>
<th>Total lesions</th>
<th>Metastases (% of total)</th>
<th>Sensitivity (%) Radiol. +CAD</th>
<th>Sensitivity (%) CAD alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (≤5mm)</td>
<td>155 (66.0)</td>
<td>25 (15.9)</td>
<td>41.9</td>
<td>31.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78.3</td>
<td>60.9</td>
</tr>
<tr>
<td>2 (6-10 mm)</td>
<td>33 (14.0)</td>
<td>20 (60.6)</td>
<td>100.0</td>
<td>84.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100.0</td>
<td>80.0</td>
</tr>
<tr>
<td>3 (&gt;10mm)</td>
<td>47 (20.0)</td>
<td>40 (88.9)</td>
<td>95.7</td>
<td>53.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>95.2</td>
<td>50.0</td>
</tr>
<tr>
<td>total</td>
<td>235 (100.0)</td>
<td>85 (36.2)</td>
<td>60.9</td>
<td>42.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>91.8</td>
<td>60.0</td>
</tr>
</tbody>
</table>

detailed results in different size classes (≤5 mm, 6 - 10 mm, >10 mm)
Conclusion

Our study demonstrates that **MDCT with CAD reliably depicts pulmonary metastases** prior to metastectomy. Lesions which were not preoperatively detected at MDCT but palpated and resected by the surgeon were rarely found to be metastases.

The results of this retrospective study are preliminary, and an **ongoing prospective study is necessary to confirm** that CT with thorough CAD-supported reporting might be sufficiently sensitive to exclude further metastases in cases of solitary pulmonary metastases. In these cases, VATS metastasectomy might be an option in the future.

**Interdisciplinary collaboration** between surgeons and radiologists is useful to ensure optimal results of pulmonary metastasectomy, and the radiologist has the crucial task to guide the surgeon especially to centrally located lesions which are difficult to palpate.


Personal Information

C. Meybaum, D. Wormanns. Department of Radiology, Evangelische Lungenklinik Berlin, Lindenberger Weg 27, Haus 205, 13125 Berlin