Pier Francesco Rambaldi

Whole-Body FDG PET Imaging in Oncology

Clinical Reports

In collaboration with
Giovanni Fontanella

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Pier Francesco Rambaldi
Dipartimento Medico Chirurgico di
Internistica Clinica Sperimentale
''F. Magrassi-A. Lanzara'', Diagnostica per Immagini
Seconda Università degli Studi di Napoli
Naples
Italy

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My heart leaps up when I behold
A rainbow in the sky:
So was it when my life began;
So is it now I am a man;
So be it when I shall grow old,
Or let me die!
The Child is father of the Man;
And I could wish my days to be
Bound each to each by natural piety.

William Wordsworth

Foreword

I am particularly pleased to write a foreword for this book written by Dr. Pier Francesco Rambaldi, Assistant Professor of Nuclear Medicine at the Second University of Naples, and addressed to the medical world, students, GPs as well as Nuclear Medicine specialists.

This manual points out the need to rationalize the prescription of diagnostic tests, particularly CT- PET, which is a task of great responsibility of each doctor, framing the diagnosis of a diverse range of oncological clinical cases in a series of medical decisions, established as a logical consequence.

Its meaning for students and young newly qualified doctors is found in the fact that, starting with the history of the individual patient (history), it reaches the diagnostic question and the evaluation of the patient. The resulting conclusions and key points at the end of each clinical case not only allows the achievement of a response to the diagnostic question, but also allows to understand the diagnosis, at the same time framing it in the broader context of the therapeutic management and guidelines for the treatment and follow-up.

I also believe this book to be an excellent expression of the academic tradition of our School of Medicine, combining in Nuclear Medicine, two of the most important branches of medicine: clinical medicine and imaging.

This book is therefore evidence of the huge commitment of those who have made their experience available to future generations.

Therefore, I hope this book will achieve the deserved consensus among students and physicians and arouse interest in all readers.

Fortunato Ciardiello

Preface

This manual is a collection of clinical cases, treating total body CT imaging with FDG -PET in Oncology. The aim of this book is to suggest an integrated approach to PET–CT, an approach that includes medical history, diagnostic question, report, conclusions and key points.

The starting point of every clinical case is a detailed medical history, which includes the definition of the disease, previous hospitalizations, diagnostic tests and therapy. Here, the nuclear medicine specialist will acquire clinic and new elements, such as radiology and laboratory tests, vital for a consistent interpretation of the metabolic images.

From the experience gained in the medical history, it is clear that the radiological reports carried out in different hospitals do not follow a standard report, but are characterized by a varied terminology, sometimes questionable, that in any case can be considered an enrichment.

In fact, drawing from the clinical and radiological-wide vocabularies, nuclear medicine reaches a critical assessment that joins the two souls of modern medicine: clinical and imaging diagnostics, both having the task to suggest the right diagnosis, the best choice of treatment and prognostic definition in the context of a PET-CT standardized report.

The diagnostic question sums up the problem formulated by the prescriber, whether family doctor or specialist, which requires the PET-CT to follow an algorithm to get to the final diagnosis. PET-CT is more frequently required during follow -up of neoplastic conditions to change the treatment plan and/or define the prognosis.

The law criminalizes both the prescriber and the diagnostician (radiologist or nuclear medicine physician) if the services are not properly justified and optimized.

In this context it must be remembered that medical exposure is carried out by a specialist (radiologist and nuclear medicine physician) upon reasoned request of the prescriber. The choice of methods and techniques capable of achieving the greatest clinical benefit with minimal individual detriment is the responsibility of the specialist, who must also consider the possibility of using alternative procedures , not based on ionizing radiation. Nuclear medicine techniques are also among the health activities involving exposure to ionizing radiation and its associated risks. While remaining within acceptable limits, special attention is still required for the workers, the public and the patients.

The report is the document which defines the nuclear medicine physician as a specialist and it is its official way of communicating with the prescriber and with those who undergo diagnostic tests. For this reason it should be clearly written and understandable, in order to be defined as the orderly description of all the pathological elements detected by PET-CT.

In the report, there are references to possible clinical or instrumental elements reported in history or at least detected by CT . This stage is the focal point of each clinical case described in this manual and is strongly supported by a wide iconography of PET, CT and PET-CT fusion images.

The conclusions are a synthesis of all the above-mentioned elements, a short, clear and concise response to the clinical question. In this phase, it is essential to define the metabolic state of the neoplastic disease both in cancer patients in the follow-up stage, and in those who underwent radio-chemotherapy or biological drugs, in particular, it is crucial to indicate the presence of a complete or partial response, or metabolic progression of pathology . The findings may include specific clinical suggestions, especially the timing of the subsequent follow-up or the need to perform additional diagnostic tests in cases of doubt. At the end of each case, there is a space dedicated to the key points, in which some pathophysiological critical elements are discussed.

The key points point out the awareness that the clinical aid is essential in order to reach a correct diagnosis and to determine the timing of the chemo-radiotherapy procedures. Just in oncology, PET-CT allows prognostic stratification that has immediate, sometimes dramatic consequences, not only on the subsequent choice of treatment, but also on the quality of life of patients and their families.

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Contributors

Gioconda Argenziano Diagnostica per Immagini, Azienda Ospedaliera Santobono-Pausilipon, Naples, Italy

Alfonso Fiorelli Dipartimento di Scienze Cardio-Toraciche e Respiratorie, Seconda Università degli Studi di Napoli, Naples, Italy

Giovanni Fontanella Dipartimento Medico Chirurgico di Internistica Clinica Sperimentale "F. Magrassi- A. Lanzara", Diagnostica per Immagini, Seconda Università degli Studi di Napoli, Naples, Italy

Roberto Grassi Dipartimento Medico Chirurgico di Internistica Clinica Sperimentale "F. Magrassi- A. Lanzara", Diagnostica per Immagini, Seconda Università degli Studi di Napoli, Naples, Italy

Luigi Mansi Dipartimento Medico Chirurgico di Internistica Clinica Sperimentale "F. Magrassi- A. Lanzara", Diagnostica per Immagini, Seconda Università degli Studi di Napoli, Naples, Italy

Floriana Morgillo Dipartimento Medico Chirurgico di Internistica Clinica Sperimentale "F. Magrassi- A. Lanzara", Oncologia Medica, Seconda Università degli Studi di Napoli, Naples, Italy

Lanfranco Musto Diagnostica per Immagini, ASL di Avellino 1, Avellino, Italy

Francesca Polverino, Boston, Massachusetts, USA

Mario Polverino Dipartimento Strutturale delle Discipline, Mediche degli Ospedali Riuniti delle Tre Valli, ASL Salerno 1, Bergamo, Italy

Pier Francesco Rambaldi Dipartimento Medico Chirurgico di Internistica Clinica Sperimentale "F. Magrassi- A. Lanzara", Diagnostica per Immagini, Seconda Università degli Studi di Napoli, Naples, Italy

Antonio Rotondo Dipartimento Medico Chirurgico di Internistica Clinica Sperimentale "F. Magrassi- A. Lanzara", Diagnostica per Immagini, Seconda Università degli Studi di Napoli, Naples, Italy

Massimo Zeccolini Diagnostica per Immagini, Azienda Ospedaliera Santobono-Pausilipon, Naples, Italy

Collaborators

Paola Nargi Medicina Nucleare—Napoli
Annarita Ianniello Medicina Nucleare—Napoli
Rossella Ferrara Medicina Nucleare—Napoli
Maria Rosaria Prisco Medicina Nucleare—Napoli
Andrea Vaccaro Medicina Nucleare—Napoli
Francesco Barbato Medicina Nucleare—Napoli
Barbara Magliulo Medicina Nucleare—Napoli
Alessia Spagnuolo - Seconda Università di Napoli—Napoli

Part I
Cholecystis and Biliary Ducts

Recurrent Gallbladder Carcinoma

1

1.1 Clinical History

70-year-old woman with gallbladder carcinoma who underwent surgery and subsequent adjuvant chemotherapy.

The follow-up to 3 years shows a peripancreatic mass suspicious for relapse:

- FNAB: recurrent carcinoma of the gallbladder.
- CT-PET: pathological increase in the consumption of glucose in the right hypochondrium which extends in the hepatic hilum and retrocavity of epiploon, towards the uncinate process of the pancreas (SUV max 6.7). This mass shows a photopenic area inside which is probably due to colliquation.
- Markers: CA19.9 = 121 U/ml (NV < 37).

Subsequently, chemotherapy is performed.

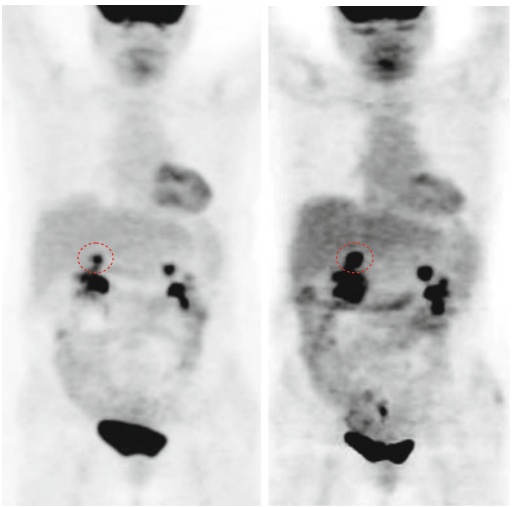

Fig. 1.1 MIP image with different intensities of printing: The pathological FDG concentration of the mass is masked by the physiological renal excretion

1.2 Diagnostic Question

Restaging after chemotherapy completed 3 weeks before, in patient with recurrent carcinoma of the gallbladder: search for lesions with a high metabolism of glucose.

1.3 Report

Presence of a mass characterized by pathological glucose consumption in the right hypochondrium which extends in the hepatic hilum and the retrocavity of epiploon, towards the uncinate process of the pancreas, SUV max 8.1. This mass shows a photopenic area inside which is probably due to colliquation. Absence of lesions characterized by abnormal metabolism in the remaining parts of the body examined.

1.4 Conclusions

Patient with recurrent carcinoma of the gallbladder treated with chemotherapy, shows persistence of high metabolism disease in today's scan (Figs. 1.1, 1.2).

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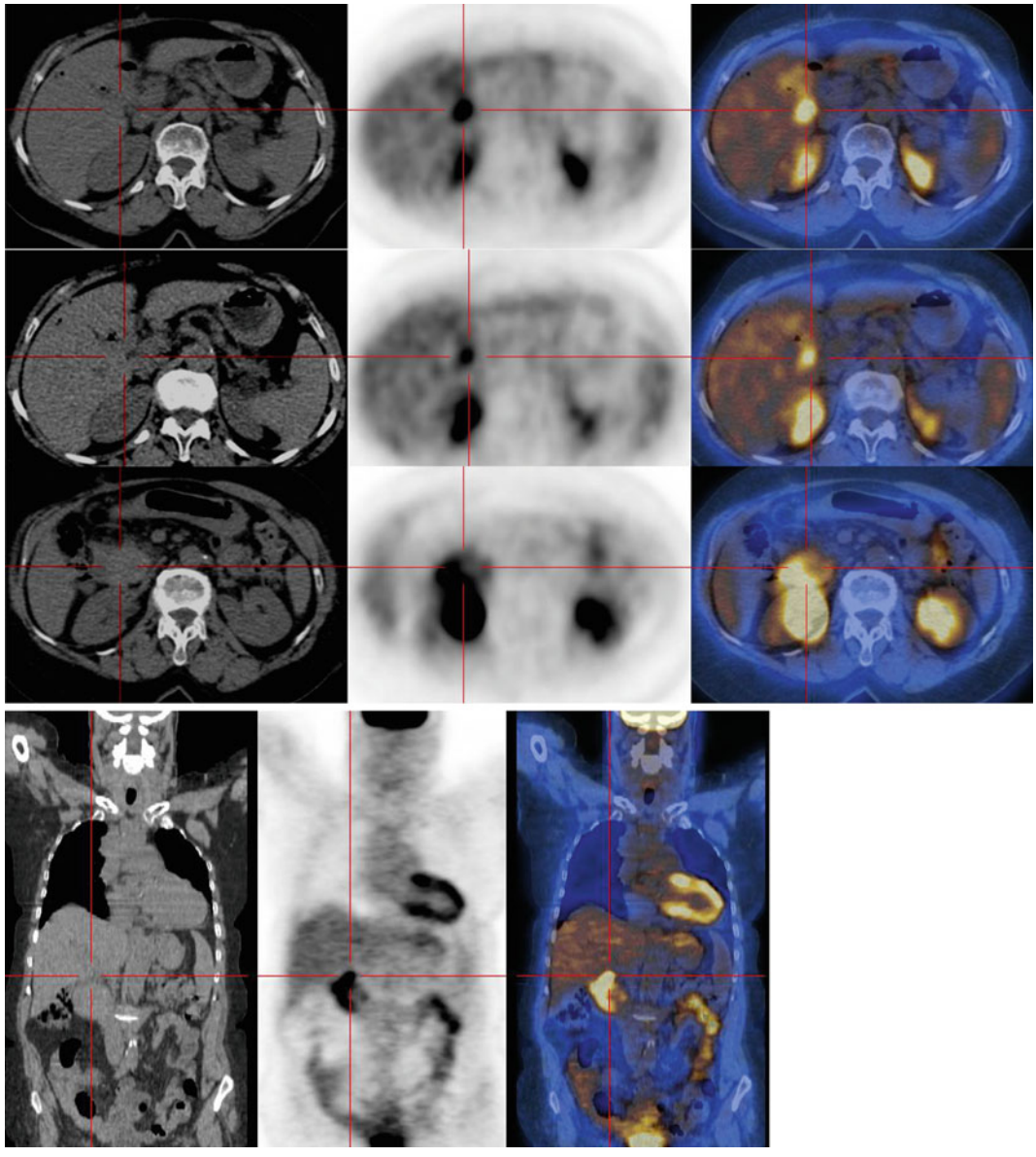

Fig. 1.2 The TC shows a *solid*, inhomogeneous mass of parenchymal density, which extends towards the hepatic hilum and retrocavity of epiploon until uncinate process of the pancreas and the kidney, from which it appears dissociable. PET has high metabolism of glucose

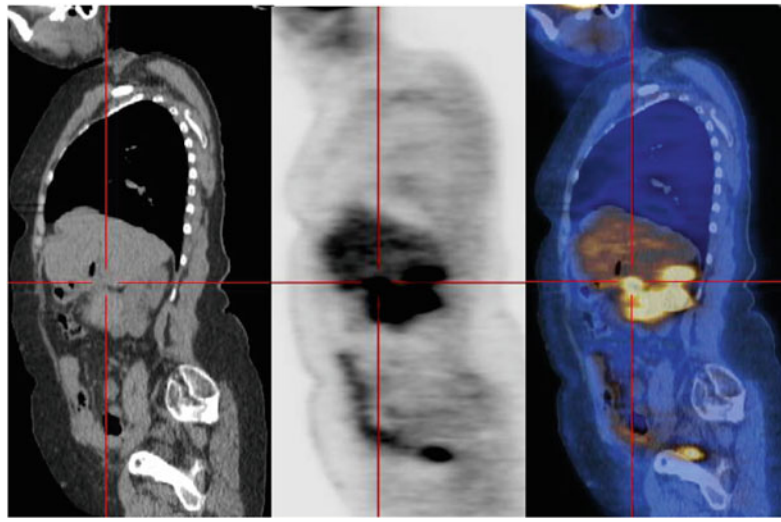

Fig. 1.2 (continued)

Recurrent Klatskin's Tumor: Peritoneal Carcinosis

2

2.1 Clinical History

67-year-old man with Klatskin's tumour, who previously underwent biliary tract resection at the common hepatic duct, with hepatic-jejunal-anastomosis and a *Roux-en-Y reconstruction* with cholecystectomy. Adjuvant chemotherapy performed.

Follow up during chemotherapy.

CT: Diffusely dishomogeneous and enlarged liver, with metallic clips in the cholecystic bed, due to previous surgery. Areas of structural dishomogeneity in the posterior portion of the VI segment, with a slightly less dishomogeneous area found in segment VIII and segment I, adjacent to the hilum, to be evaluated after contrast.

- PET-FDG: Diffusely dishomogeneous liver with focal uptake areas found in segments VI, VII and VIII.

Chemotherapy went on.

2.2 Diagnostic Question

Restaging after chemotherapy in patient with Klatskin's tumour: search for lesions with elevated glucose metabolism.

2.3 Report

Mild focal glucose uptake in two hepatic nodules, both due to local recurrence, the first in the right biliary tract, just above the site of previous surgery, SUV max 3.5 (Fig. 2.1a), the other at the hilum, adjacent to the metallic clips, SUV max 2.5 (Figs. 2.1b, 2.2).

Some abdominal centimetric nodules due to carcinosis are found, showing slight glucose uptake, SUV max 2.3 (Fig. 2.1c). Millimetric nodule at the right diaphragmatic pleura, with pathological metabolism, SUV max 1.1 (Fig. 2.3).

The left kidney is small and does not show neither uptake nor washout of the marker, due to severe obstructive hydronephrosis, as shown in CT: it's a typical morpho-functional case of 'excluded kidney' (Fig. 2.4).

2.4 Conclusions

PET scan shows a metabolic activity which could be due to local recurrence of disease, associated with peritoneal carcinosis and pleural involvement.

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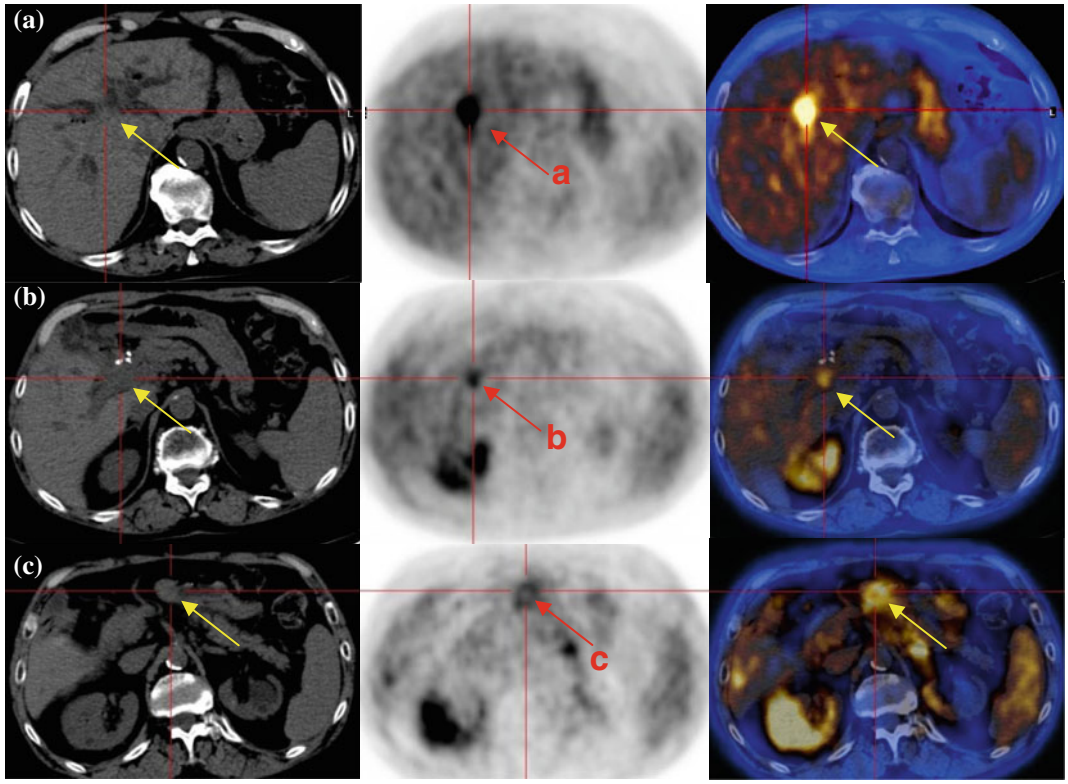

Fig. 2.1 Mild focal glucose uptake in two hepatic nodules, both due to local recurrence

In miliary carcinosis, characterized by subcentimetric lesions, PET scan can have a limited accuracy: in this patient, the MIP image shows a modest glucose metabolism of the peritoneal and pleural nodules; only the bigger hepatic recurrence shows an increase of the FDG uptake. CT scan is then compulsory for a comprehensive understanding of the functional data.

2.5 Key Points

The scan shows severe hydronephrosis; thus, a differential is required (Fig. 2.1f):

- calcolosis,
- postoperative complications,
- congenital diseases.

When these diseases are not found in previous radiological examinations, an occult peritoneal carcinosis has to be suspected; it has to be searched for in all of the CT and PET images. Every dubious lesion, which could be part of a carcinosis, has to be reported, even when it shows low FDG metabolism.

You do not have to forget that the patient is an oncological one:

When the clinical conditions are poor and the PET scan does not show high metabolism lesions, a low metabolism recurrence of disease has to be suspected.

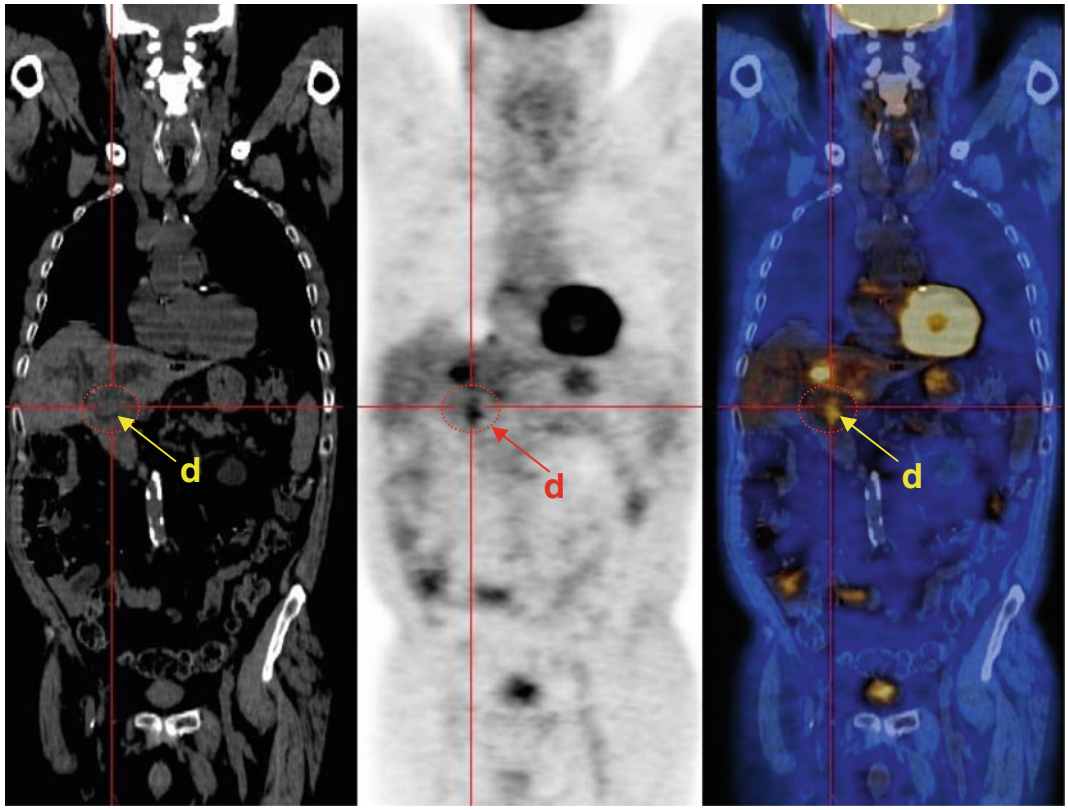

Fig. 2.2 Hepatic nodule at the hilum

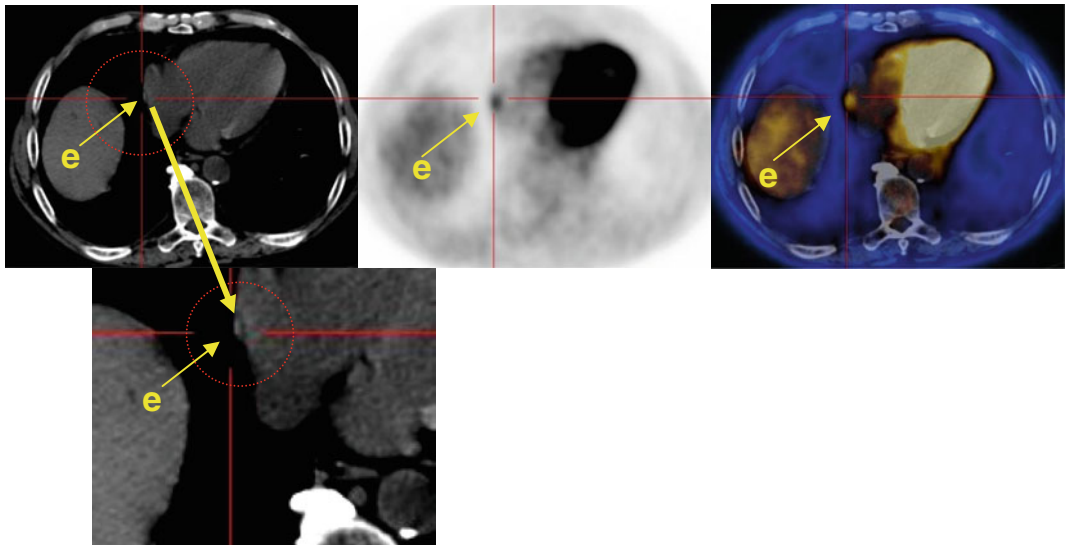

Fig. 2.3 Millimetric nodule at the right diaphragmatic pleura, with pathological metabolism, SUV max 1.1

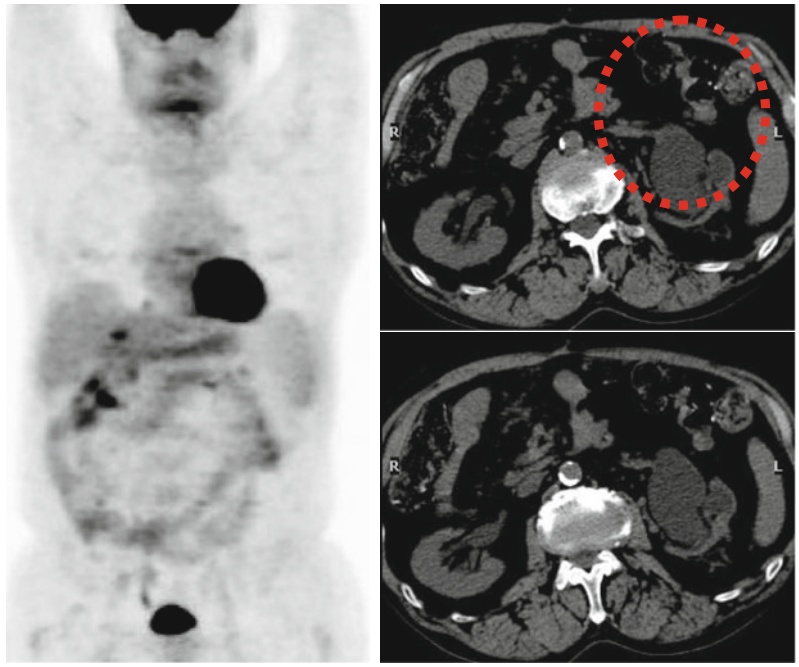

Fig. 2.4 Typical morpho-functional case of excluded kidney

- In this patient, the limited metabolism of the lesions could be due, at least in part, to the chemotherapy.

Pleural involvement is a sign of the advanced stage of disease.

Part II
Head-Neck

Parotid Cancer Recurrence and Metachronous Lung Cancer

3

3.1 Clinical History

78-year-old man who previously underwent surgery for squamous cell carcinoma of the right ear. After 6 months he underwent subtotal parotidectomy and right latero-cervical lymph node ipsilateral dissection. Adjuvant radiotherapy is then performed.

- Histology: infiltrating squamous cell carcinoma contiguous to the skin. Intermediate degree of differentiation, G2. Surgical resection margins are free. 10 lymph nodes are free of tumor localization.
  Reassessment after surgery.
- Contrast-enhanced CT: Moderate tissue thickening of the skin in the right latero-cervical area due to scarring phenomena. 2 cm-pseudonodular area behind the ipsilateral mandibular angle.
  Re-evaluation after 3 months.
- Contrast-enhanced CT: solid nodular lesion in the right parotid region, scarcely dissociable from locoregional vascular structures, associated with diffuse thickening tissue and latero-cervical adenopathy. Presence of a 3 cm-lymph node 3 at the left lung hilum and some repetitive confluent small nodules (biggest dimension 2 cm) in the context of the ipsilateral upper lobe.

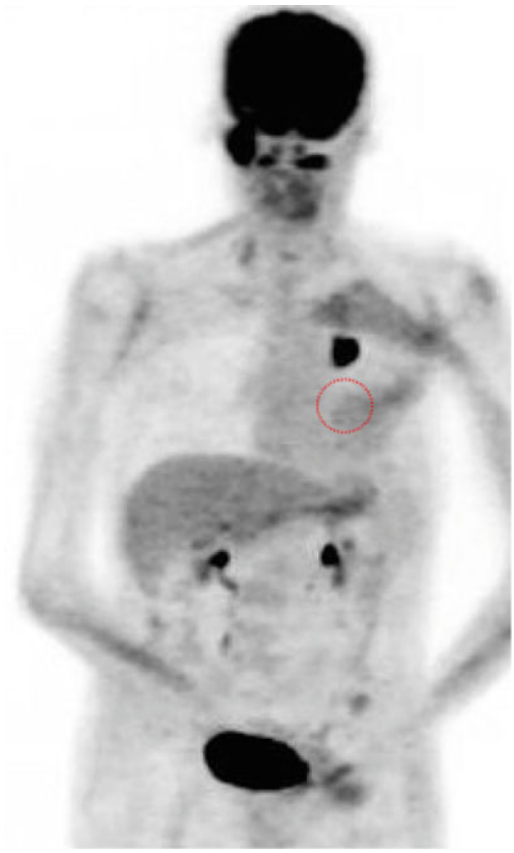

Fig. 3.1 The PET scan shows loco-regional recurrence of disease in the right parotid area with metachronous lung cancer

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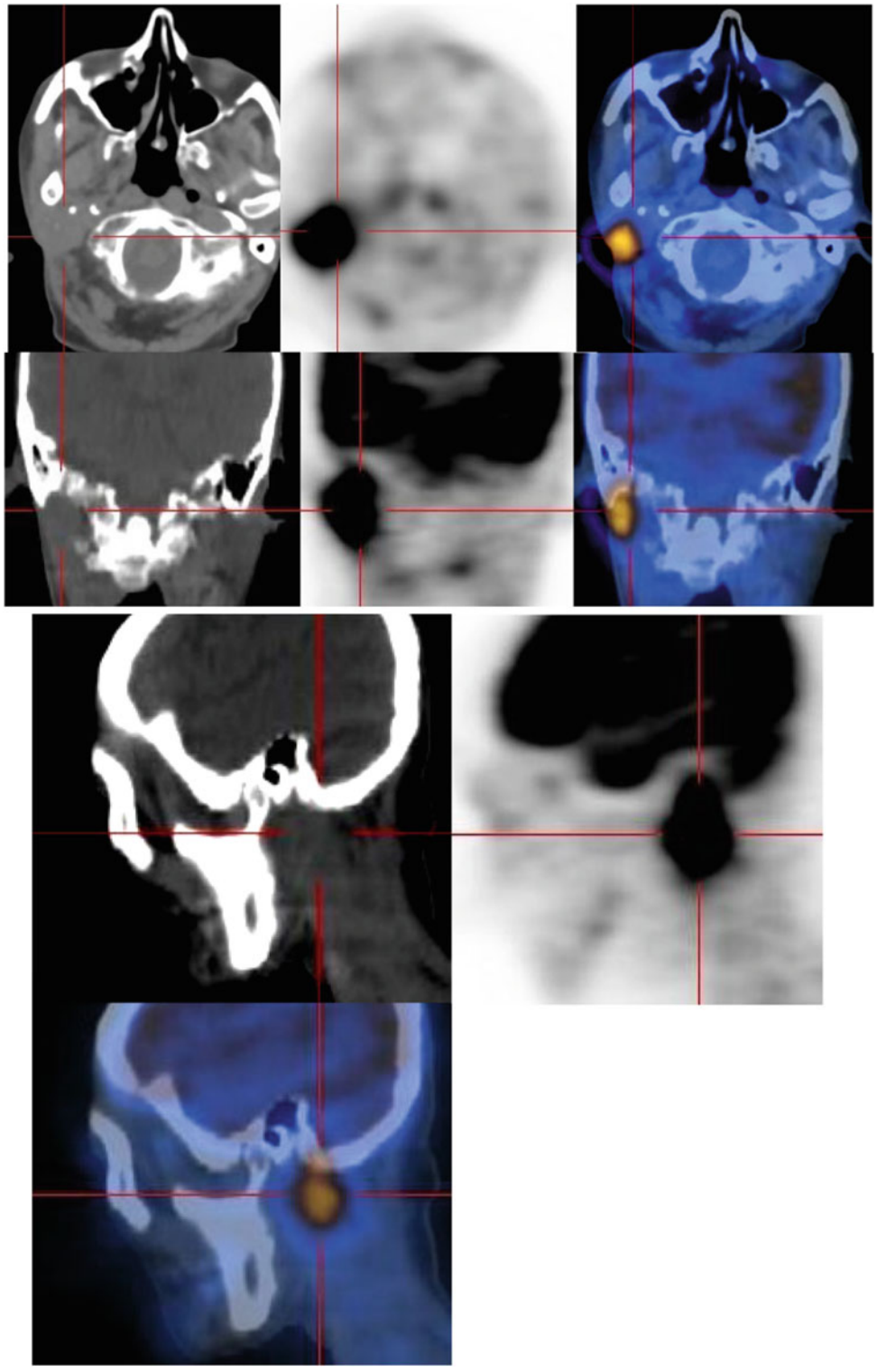

Fig. 3.2 The MIP image demonstrates the intense metabolism of the right ear-parotid nodule

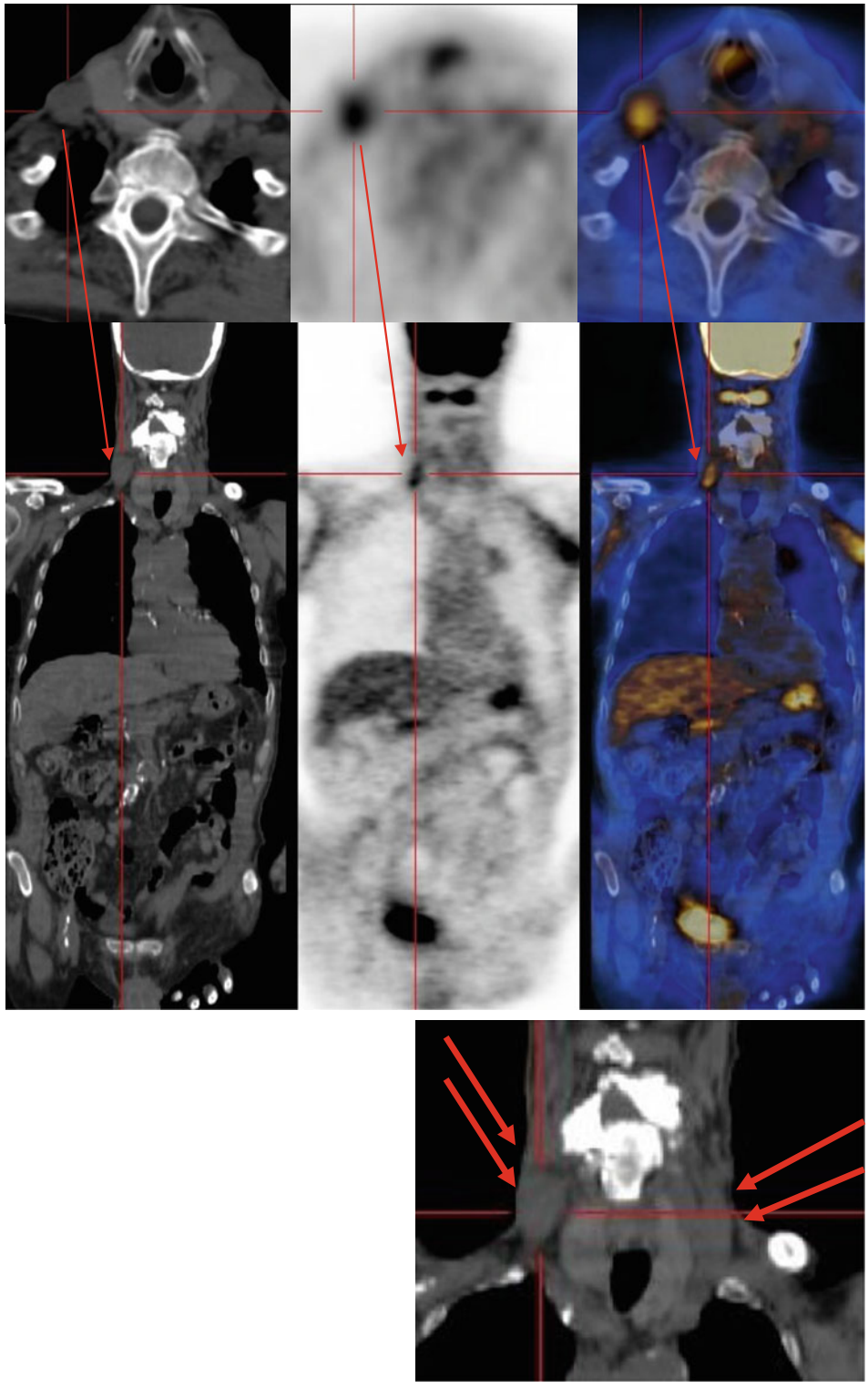

Fig. 3.3 PET: limited increase of glucose metabolism in the lower left laterocervical area

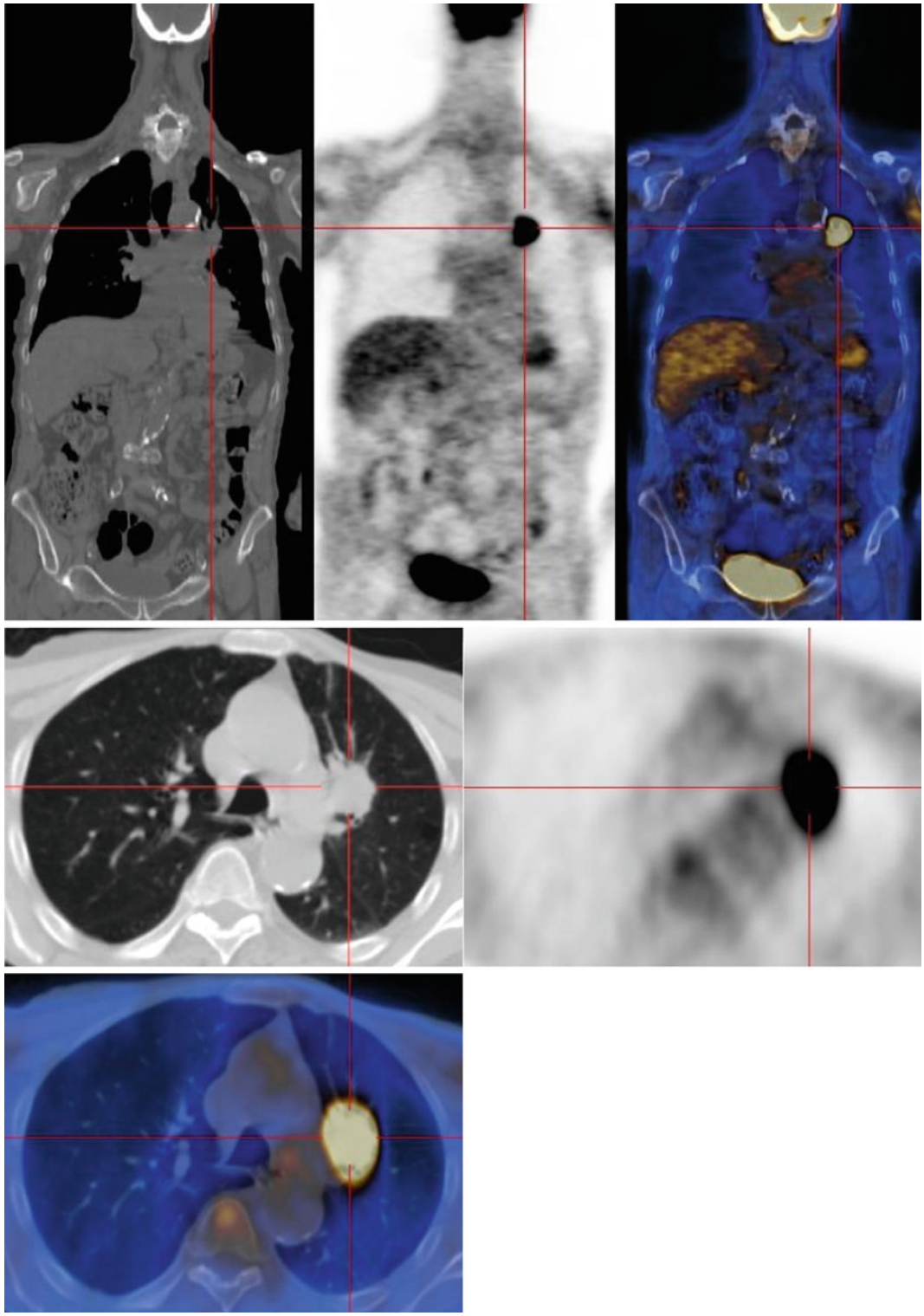

Fig. 3.4 CT-PET: at the lingula, a solid speculated mass with irregular margins, indistinguishable from the hilum, which has intense carbohydrate consumption

3.2 Diagnostic Question

Search for focal lesions with high glucose metabolism in patient with squamous cell carcinoma of the ear after surgery: restaging.

3.3 Report

Nodule with a high consumption of glucose in the ear—right parotid region extending to the temporal and sphenoid bones, which are infiltrated, SUV max 12.

Left lung mass with extensive metabolism, not clearly dissociable from the ipsilateral hilum, SUV max 16.

Limited metabolic activation in the lower right laterocervical area, indicating a muscular nonspecific concentration of FDG, SUV max 2.2.

3.4 Conclusions

The PET scan shows loco-regional recurrence of disease in the right parotid area, extending to the temporo-sphenoidal area, with metachronous lung cancer (Fig. 3.1).

The MIP image demonstrates the intense metabolism of the right ear-parotid nodule and left pulmonary mass.

Widespread activation of some muscle groups of the neck is shown, with the arms presenting an antalgic attitude.

In the right ear—parotid CT-PET a solid, uneven nodule can be seen, characterized by intense consumption of glucose (Fig. 3.2).

In the axial images it is evident the locoregional bone infiltration of the temporal and sphenoid, that appear eroded. See also (Figs 3.3, 3.4).

CT shows no focal adenopathies, so this can be considered as non-specific accumulation, caused by muscle activation.

3.5 Key points

- It is not easy to determine whether lung mass is a metastasis or metachronous cancer.
- The biopsy in these cases is not always conclusive.

You can suspect a metachronous cancer here because

- CT-PET shows a lung mass of considerable size;
- at their onset secondary injuries are multiple and smaller;
- metastases are generally mantellar, rarely involving the hilum;
- squamous tumors frequently have synchronous or metachronous localizations.