Imaging features of (a)melanotic metastasis to the major abdominal organs: tips and tricks

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Learning objectives

No single imaging modality can accurately detect and stage patients with Malignant Melanoma (MM) correctly. The different imaging modalities for detection and lesion characterization depicted here are complementary to each other. Follow up imaging needs to be tailored for every patient specifically concerning the metastatically involved sites and the completeness of the undergone surgery. The learning objectives of this educational exhibit are therefore twofold:

1. To illustrate the spectrum of manifestations of MM metastases to the major abdominal organs using Multi Detector Computed Tomography (MDCT), Magnetic Resonance Imaging (MRI) and $^{18}$F-fluorodeoxyglucose ($^{18}$F-FDG) Positron Emission Tomography (PET). The most important imaging sequences are T1-Weighted Imaging (WI), Diffusion Weighted Imaging (DWI) and Contrast Enhanced (CE) imaging.

2. To describe diagnostic clues that differentiate melanotic from amelanotic metastases.
Background

1. General considerations

The incidence of MM has increased dramatically over the past few decades. (Cutaneous) MM has a natural very high metastatic capacity and is well known for its tendency to spread to unpredictable sites. Only 4% of patients with MM will be diagnosed with metastatic disease to the abdominal organs although this percentage is higher in autopsy series. Amelanotic melanoma is a subtype of MM in which there is less melanin formation compared to the melanotic form (1).

2. Modes of dissemination

Metastatic patterns of MM include: (1) satellite lesions around the (scar of the) primary tumor; (2) in transit metastases between the primary tumor and the first regional lymph node; (3) lymph node involvement and (4) hematogeneous dissemination (2).

Abdominal metastases of MM due to hematogeneous spread are mainly observed in the liver, gallbladder, spleen, pancreas, small bowel and adrenal glands. MM metastases are in the top 3 of primary tumors disseminating to the spleen, gallbladder, pancreas, small bowel and adrenal glands.
1. Imaging modalities

MM metastases are classically detected as volume expansive masses in the abdominal organs. Large lesions may have areas of necro-hemorrhagic changes. They contain a variable amount of melanin giving this lesion its macroscopically well-known dark black color. These metastases exhibit generally hypervascular behavior which is very important for optimal detection on MDCT. MM metastases may become hypovascular when the amount of melanin and/or necro-hemorrhagic changes is high.

The combination of MDCT and $^{18}$F-FDG Positron Emission Tomography (CT-PET) has enabled to combine morphological and functional data in a single examination. The combination of these complementary techniques has increased diagnostic accuracy significantly in different malignant tumors (3). However, not all metastases of MM are $^{18}$F-FDG PET avid. Metastases with a large amount of melanin or necro-hemorrhagic changes can be $^{18}$F-FDG PET negative.

Melanin produces shortening of the T1-relaxation time due to its paramagnetic properties. Therefore metastases of melanotic MM yield bright lesions in contrast to the amelanotic subtype on T1-WI. The best sequence is T1 Gradient Echo (GRE)-WI with Fat Suppression (FS) for detection because these lesions lose their normal high signal on T2 Half-Fourier Acquisition Single Shot Turbo Spin Echo (HASTE)-WI (Fig. 1 on page 7). Unfortunately, in most MM metastases the concentration of melanin is too low to increase the signal intensity on T1-WI. Therefore most of them will have the same appearance as classic metastases. Other substances that also appear hyperintense on T1-WI are summarized in figure 2 (Fig. 2 on page 7). Also, the specific hypervascular nature of MM metastases seen on CE imaging (Fig. 3 on page 7) can aid the radiologist in the differential diagnosis but is not always present. In most cases -as in our case series- the metastases show moderate hypervascularity. In addition, DWI is an excellent tool to detect metastatic spread of MM (Fig. 5 on page 9, Fig. 8 on page 10 and Fig. 12 on page 13). These lesions show a persistent high signal on images with high b-values ($b = 600, 800$ and $1000$).

2. Abdominal metastases

In the next section we will discuss the major key points and concomitantly illustrate the most frequent encountered manifestations of MM metastases to the major abdominal organs such as the liver, gallbladder, spleen, pancreas, gastrointestinal tract and adrenal glands. All the cases presented are histologically proven.
Liver

Metastases are the most common malignant liver lesions and are about 18-40 times more common than primary liver tumors. Liver metastases are most often detected with MDCT. They may be hypervascular and are in approximately 14% of the cases undetectable in the portal venous phase (2). Complete surgical resection of liver metastases prolongs survival in eligible surgical candidates. Detection, quantification and localization of liver metastases are crucial as the imaging findings and corresponding therapy alter the patients outcome (4). Figures 4, 5 and 6 demonstrate amelanotic MM liver metastasis that lacks hyperintensity on T1-WI. The lesion demonstrates conspicuous hyperintensity on T2-WI. Also, the specific hypervascular character is absent (Fig. 4 on page 8, Fig. 5 on page 9 and Fig. 6 on page 9).

Gallbladder

Hematogenous metastases to the gallbladder usually develop as serosal implants, progressively growing as polypoid masses. These lesions are mostly detected at imaging or autopsy, being usually asymptomatic. The most common presentation of symptomatic metastases to the gallbladder is acute cholecystitis followed by obstructive jaundice. Hemobilia and biliary fistula are rare complications (5). We present the case of a 57-year-old female patient with complaints of gallstone disease. MDCT revealed two intraluminal masses not compatible with gallstones. Corresponding CT-PET revealed $^{18}$F-FDG avidity (Fig. 7 on page 10). Subsequent MRI showed only slightly hyperintensity of the lesions with obvious diffusion restriction on DWI (Fig. 8 on page 10).

Spleen

Splenic involvement by metastases is relatively uncommon and occurs with a frequency of 0.6 to 7.1% in autopsy series. Tumors that most commonly metastasize to the spleen are MM (34%), breast (12%), ovary (12%), colon (10%) and lung (9%). Splenic metastases usually are seen in patients with advanced disease. We present a case of a 70-year-old woman with biopsy proven metastases of MM in the liver with subsequent metastatic spread to the spleen detected with MDCT 2 months after initial diagnosis (Fig. 9 on page 11 and Fig. 10 on page 12).

Pancreas

Hematogenous metastases are uncommon and are usually seen in patients with advanced disease. The most common primary tumors that metastasize to the pancreas are renal cell carcinoma, MM and lung cancer. The 5-year survival of patients with solitary
pancreatic metastasis of MM is 12% and 5-year survival of multiple metastases is 0%. Following complete resection of a solitary metastasis, the 5-year survival increases to 18% (6). It is therefore of the essence to accurately stage those patients since surgical treatment in elective patients alters the outcome. We present the case of a 66-year-old man with a subungual melanoma followed by amputation of the index finger. One year later he developed a solitary pancreatic metastasis that was resected successfully. He remained disease free up to now (Fig. 11 on page 13). We also present the case of a 66-year-old woman with pancreatic and liver metastases that were not seen on MDCT and PET and thereby beautifully illustrating the complementary value of MRI (Fig. 12 on page 13 and Fig. 13 on page 14).

Gastrointestinal tract

Tumors of the small bowel are rare, accounting for about 3-6% of all gastrointestinal (GI) neoplasms, though it covers more than 90% of the intestinal surface. However, intestinal involvement of metastatic cancer is common, with varying incidence among different malignancies. Such involvement, mostly in the form of diffuse peritoneal carcinomatosis, has been reported in up to 5-10% of cases in neoplasms such as breast cancer and malignant melanoma. Only 2 to 4% of patients with melanoma will be diagnosed with GI metastases during the course of their disease. GI metastases of melanoma are reported more commonly in autopsy series (50-60%) (Fig. 14 on page 15). Distribution of metastases of MM can be summarized as follows: small bowel (75%), colon (25%) and gastric involvement (16%). Complications of small bowel and colonic metastases may act as a lead point for intussusception, obstruction or hemorrhage (2). However, obstruction caused by (MM) metastases is much less frequent than primary tumors.

Adrenal gland

Hematogenous metastases are the most common malignant lesions of the adrenal glands and are found in up to 27% of the patients with malignant epithelial tumors. The most common primary sites of tumors comprise the lung, kidney and MM. Metastases can be uni- or bilateral and exhibit low and high signal intensities on respectively T1- and T2-WI. They show progressive enhancement after intravenous gadolinium contrast administration. No fast wash out and lack of signal loss on in and opposed phase imaging is typical (Fig. 15 on page 16 and Fig. 16 on page 16).
**Fig. 1:** Abdominal MRI of a 55-year-old man. GRE T1-WI without FS demonstrates the hyperintensity of melanin containing lesions (arrows). The lesions are even more appreciated on sequences with FS due to the high signal intensity compared to the signal intensity of normal liver parenchym (arrows).

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**Fig. 2:** Summary of substances that show hyperintensity on T1-WI.

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**Fig. 3:** Abdominal MRI of a 58-year-old woman. Imaging features of MM metastasis with poor melanin content. The lesion appears hyperintense on T2 with FS- and hypo-intense on GRE T1-WI (arrows). Typical hypervascularity can be seen on arterial phase imaging after intravenous gadolinium contrast administration. In the portal venous phase, the lesion appears isointense in comparison to the surrounding liver parenchyma (arrows).

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**Fig. 4:** Abdominal MDCT and CT-PET of a 60-year-old woman. Hypovascular liver MM metastasis on MDCT portal phase imaging and corresponding 18F-FDG avidity on CT-PET (arrows).
**Fig. 5:** Abdominal MRI of the same patient as in figure 4. The lesion in liver segment VI is hyperintense on T2-WI (arrow) as seen in most metastases. DWI clearly demonstrate diffusion restriction with high signal intensity on images with high b-values (b = 600 and 1000) and corresponding low signal intensity on the ADC-map (arrows).

**Fig. 6:** Abdominal MRI of the same patient as in figure 4. No intracellular lipid content is present in the lesion: no signal drop can be demonstrated on GRE T1 in and opposed phase imaging. The lesion shows no obvious hyperintensity on T1-WI and lacks its typically described hypervascular nature on CE imaging (arrows).
Fig. 7: Abdominal MDCT and CT-PET of a 57-year-old woman. MDCT shows two metastases in the gallbladder (arrows) that both are 18F-FDG avid (arrows).

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Fig. 8: Abdominal MRI of the same patient as in figure 7. Moderate hyperintense gallbladder lesion on GRE T1-WI (arrow). The hyperintense central necrotic portion of the lesion is better appreciated on T2-WI (arrow). The lesions clearly demonstrate diffusion restriction with hyperintensity on images with high b-values (b = 600 and 1000) and corresponding hypointensity on the ADC-map (arrows). Lesion enhancement can be appreciated on CE imaging (arrows).

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**Fig. 9:** Abdominal MDCT and MRI of the abdomen in a 70-year-old woman. MDCT shows a peripheral enhancing lesion (arrow). MDCT guided biopsy revealed the typical macroscopical well known black color of melanin. The lesion is hyperintense on T2-WI without and with FS (arrows). No signal drop is observed on GRE T1-WI in and opposed phase imaging (arrows). This lesion also lacks the typical hypervascular aspect on CE imaging (arrows).

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**Fig. 10:** Abdominal MDCT of the same patient as in figure 9. MDCT illustrates two splenic metastases (arrows) two months after initial diagnosis illustrating rapidly evolving disease.

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**Fig. 11:** Abdominal MRI of a 66-year-old man. Solitary pancreatic metastasis: prominent hypointense on T2-WI and partial hyperintense on GRE T1-WI with FS (arrows). No signal drop on GRE T1 in and opposed phase imaging can be appreciated (arrows). The lesion lacks the typically described hypervascular nature on CE imaging (arrows). Surgical specimen after whipple procedure clearly demonstrates the solitary nodular mass. Immunohistochemical identification of S-100 protein confirms the presence of melanoma cells.

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**Fig. 12:** Abdominal MRI of a 66-year-old woman. Pancreatic lesion with moderate hyperintensity on T2-WI and hypointensity on GRE T1 in and opposed phase imaging (arrows). DWI clearly shows diffusion restriction with high signal intensities on images with high b-value ($b = 1000$) and corresponding hypointensity on ADC-map (arrows). Again, no hypervascular nature is detected after intravenous gadolinium contrast administration.

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Fig. 13: Abdominal 18F-FDG PET and MDCT of the same patient as in figure 12. Corresponding PET examination shows no 18F-FDG avidity. On MDCT the metastasis is also isodense with the surrounding pancreatic tissue and therefore cannot be delineated from normal tissue.

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Fig. 14: Abdominal MDCT of a 39-year-old-man. MM metastasis with aneurysmal dilatation of the small bowel lumen (arrows) mimicking lymphoma.

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Fig. 15: Abdominal MDCT of a 42-year-old-woman. Axial and coronal reformatted images demonstrate an unilateral nodular mass in the right adrenal gland (arrows).

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Fig. 16: Abdominal MRI of the same patient as in figure 15 two months later. Bilateral metastases of MM in the adrenal glands. Both masses show a necro-hemorrhagic appearance on T2-WI (arrows). No signal loss can be seen on GRE T1 in and opposed phase imaging (arrows). After intravenous gadolinium contrast administration no fast wash out is seen on portal venous phase imaging (arrows).

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Conclusion

The aim of this exhibit is to familiarize the radiologist with imaging features of metastatic (a)melanotic MM.

Amelanotic melanoma is a subtype of MM in which there is less melanin formation compared to the melanotic form, therefore influencing the signal characteristics and contrast behavior of metastases.

The classically described hyperintensity of melanin on T1-WI and hypervascularity on CE imaging of MM was - in our series - only present in a minority of cases. The authors believe that this given feature clearly demonstrates the true spectrum of various manifestations of MM metastases.

Abdominal metastases of MM due to hematogeneous spread can be primarily observed in the liver, spleen, gallbladder, pancreas, small bowel and adrenal glands as illustrated in our case series.

Metastases of MM are in the top 3 of primary tumors disseminating to the spleen, gallbladder, pancreas, small bowel and adrenal glands.


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