Peritoneal carcinomatosis in abdominal emergencies: the comparison of US and CT findings by ROC analysis

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Purpose

Patients with malignant disease very frequently require emergency treatment. On one hand this could be expected due to their bad health conditions, especially with confirmed disseminations of malignant diseases. On the other hand unexpected progression of their disease forces them to seek urgent medical care.

Patients with peritoneal carcinomatosis could be expected to require emergency treatment. Their diagnosis can be established using different diagnostic modalities.

The purpose of our work is to promote the value of US findings, as the first diagnostic step, and to compare them with CT in abdominal emergencies due to malignant diseases. CT scanning is considered the gold standard for diagnosing peritoneal carcinomatosis\(^1\),\(^2\), due to its high sensitivity and specificity.

Metastatic disease or peritoneal carcinomatosis can affect both, the peritoneum and the omentum or mesentery\(^3\),\(^4\). The most common primary tumors that spread to or invade the peritoneum, according to our experience, are tumors of the colon, ovaries, and stomach, but they also comprise pancreatic, endometrial, and breast cancer, melanoma, sarcoma and lymphoma. Considering the incidence of malignant diseases, colon cancer is the most common cause of peritoneal carcinomatosis in our institution (28%).
Methods and Materials

In the last six years we have collected ultrasound and CT criteria of peritoneal implants in 192 patients (of more than 3000 emergency cases), using the high resolution US equipment and 16th slice CT. The collected diagnostic findings were processed by receiver operating characteristics (ROC) analysis to perform the diagnostic useful image data.

Due to the huge variety of CT and ultrasound reports, and in order to establish the right diagnosis examination aimed at finding peritoneal deposits requires:

• Knowledge of peritoneal cavity anatomy,

• Good skills at performing an ultrasound examination and good knowledge of CT,

• Good diagnostic equipment, both for US and for CT

• Good cooperation with colleagues, necessary for an unbiased second opinion.
Results

Intraabdominal spread of malignant tumors can occur via four main paths:

- Direct invasion, mostly along insertions of the mesentery and ligaments (Fig.1 on page 7., Fig.2 on page 7 and Fig. 3 on page 8.)\(^6,7\).
- Intraperitoneally, with tumor cells being spread across the peritoneal cavity via intraabdominal fluid (Fig.4. on page 9 and Fig. 5. on page 10)\(^6,8,9\).
- Lymphatic dissemination through lymph vessels into the mesentery and ligaments (Fig.6. on page 11, 7. on page 12 and 8. on page 13)\(^6,13,15\).
- Hematogenous dissemination very often involves thickening of the intestinal walls (Fig. 9. on page 14, 10. on page 15 and 11. on page 16)\(^19,20\).

Most common CT and ultrasound findings in peritoneal carcinomatosis was ascites (Fig.12. on page 17, 13. on page 18, and 16. on page 21 by CT, Fig.14. on page 19 and 15. on page 20 by US).

The Sensitivity of ascit by US was 75% and in CT-ies 81, 2% (Fig. 61. on page 66 and Fig. 63. on page 68).

CT findings in peritoneal carcinomatosis were also multiple mesenteric masses of different sizes (0,5 to 12cm) and with irregular contours, especially in colon, stomach and ovarian carcinoma (Fig. 17. on page 22 and 18. on page 23).

The Sensitivity of CT, looking at the tumor size (over 2cm) was 93,7%, with the accuracy of 95,1%, and for undefined block masses 75%, with accuracy of 77,4% (Fig.63. on page 68 and Fig. 64. on page 69). Localization of deposits, especially in omental sac (Fig. 17. on page 22 and 18. on page 23), also was significant (stomach, colon and ovarian cancer origin), with sensitivity of 81,2%, and accuracy of 85,5% (Fig. 63. on page 68 and Fig. 64. on page 69).

The best sensitivity and accuracy were performed by US reports (Fig.19. on page 24) of thickened undefined bowel wall (77.6%, 85,4%), thickened abdominal wall with attached masses (Fig.20. on page 25), sensitivity 66.6%, accuracy 81,2%) and for solid abdominal masses (Fig.21. on page 26), sensitivity of 66.6%, and accuracy of 83.3% (Fig. 61. on page 66 and Fig. 62. on page 67).

Very often CT finding in peritoneal carcinomatosis was "omental cake" sign (when tumor replaces the whole omental fat) and can be seen as a confluent soft tissue-like mass, contiguous with the anterior wall and the trasverse colon (Fig. 22. on page 27 and 23. on page 28)\(^13,19\). The sensitivity of undefined block masses in our investigation was by CT was 75%, with accuracy of 77,4% (Fig. 63. on page 68 and Fig. 64. on page 69).
Ultrasound reports for "omental cake" (Fig. 24. on page 29 and 25. on page 30) in our investigation showed sensitivity of 70.3%, with accuracy of 75.6%.

Most common CT findings in peritoneal carcinomatosis were "Misty" omentum or mesentery, with small nodules and metastases in fatty tissue (Fig. 26. on page 31 and 27. on page 32), but there were often unclear answers?

The sensitivity of solid nodular masses on CT (Fig. 28. on page 33 and 29. on page 34) was not very high, 69.3%, but the accuracy was sufficient - 83.3% (Fig. 63. on page 68 and Fig. 64. on page 69). It depends much on size (over 1cm) and localization (surrounded with lucent peritoneal fat and near the abdominal wall).

In some cases, recognizing and evaluating peritoneal deposits by CT can be difficult if there are no ovarian masses, but if peritoneal disease is present the diagnosis is easier to establish (Fig. 30. on page 35 and 31. on page 36).

By ultrasound nodular deposits were recognized by size (Fig. 32. on page 37), over 2cm and localization (Fig. 33. on page 38 and 34. on page 39), near the abdominal wall, but with low sensitivity of 57.6%, and accuracy 69.3% (Fig. 61. on page 66 and Fig. 62. on page 67).

Post contrast enhancement on CT was very useful in visualization of "omental cake" (Fig. 22. on page 27 and 23. on page 28), nodular deposits (Fig. 36. on page 41), and thickened parietal peritoneum (Fig. 17. on page 22) with sensitivity of 68.7% and accuracy of 72.6% (Fig. 63. on page 68 and Fig. 64. on page 69).

Our imaging of peritoneal carcinomatosis was based on years of our own experience, as well as on the experience of other researchers. Our main goal was to assess the significance of certain diagnostic criteria and characteristics as accurately as possible.

Results were obtained using ROC (receiver operating characteristic) analysis, which determines sensitivity and specificity, as well as positive and negative predictive values, accuracy of diagnostic methods and single criteria and characteristics of pathological findings on US and CT examinations.

Ultrasound examinations mostly reveal solid hypo- or heteroechoic (rarely hyperechoic) lesions (Fig. 32. on page 37, 33. on page 38, 34. on page 39, 35. on page 40, 37. on page 42, 41. on page 46, 43. on page 48 and 45. on page 50). Their visualization largely depends on their size.

Depending on the US transducer, deposits can be seen adjacent to the anterior abdominal wall (Fig. 20. on page 25,21. on page 26,34. on page 39, 39. on page 44 and 41. on page 46).

Ultrasound examinations also reveal solid changes of the abdominal wall, sometimes as subcutaneous deposits (Fig. 34. on page 39 and 41. on page 46).
Depending on the transducer, deposits can be seen deeper in the abdomen, in the omental pouch or peritoneal cavity (Fig. 43. on page 48 and 45. on page 50).

Deposits in the parietal peritoneum can be seen subphrenically in form of hypoechogenic nodular changes, or irregular peritoneal thickening adjacent to the liver and spleen, and are mostly marked by ascites (Fig. 16. on page 21 and 17. on page 22).

Nodular deposits near the abdominal wall should look like as lump nodes (Fig. 47. on page 52 and 48. on page 53).

Disension of bowel loops were one of the most important signs in decision making process in emergency cases. It could lead to urgent surgical treatment. Clinical observation and the etiology of disease very often dispel our fears.

CT criteria’s were distended bowel loops, with slowdown of bowel’s content, sometime with gas-liquid levels, and sometime with evident signs of sub-occlusion, or occlusion (Fig. 49. on page 54 and 50. on page 55). The sensitivity of CT features was 62,5%, with accuracy of 74,2%.

US criteria’s were not so clear. Distended, but very often undefined bowel loops, with thickened wall were not very significant (Fig. 51. on page 56, 52. on page 57, 53. on page 58 and 54. on page 59), with sensitivity of 55,7%, and accuracy of 75,7% (Fig. 61. on page 66 and Fig. 62. on page 67). Our diagnostic assume lead us to the other diagnostic modalities (Fig. 50. on page 65.).

The best Positive predictive value (PPV) of 92% for US features (Fig. 61. on page 66) were shown for sub-occlusions (Fig. 55. on page 60 and 56. on page 61) and 85,7% for solid abdominal masses (Fig. 57. on page 62 and 58. on page 63).

The best predictive positive value of CT findings (Fig. 63. on page 68) were found depending on tumor mass size (96,8%) (Fig.59. on page 64), localization (89, 6%) (Fig.60. on page 65) and sub-occlusions (83,3%) (Fig.49. on page 54).
**Fig. 0:** Neoplasm of the ascending colon with direct invasion of the adjacent fat tissue and nodular deposits.

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**Fig. 0:** Neoplasm of the sigmoid colon with direct invasion of the adjacent fat tissue and nodular deposits (CT findings).

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Fig. 0: Ultrasound appearance in the same patient with infiltrated large bowel surrounded with peritoneal deposits.

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Fig. 0: Nodular bilateral paracolic thickenings of the peritoneum, colon cancer origin (CT).

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Fig. 0: Nodular bilateral paracolic thickenings of the peritoneum, colon cancer origin (ultrasound view in the same patients as in Fig.4.).

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**Fig. 0:** CT features of para-vesical peritoneal infiltration in urinary bladder cancer.

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Fig. 0: CT features of lymphatic dissemination in urinary bladder cancer.

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Fig. 0: Ultrasound features of lymphatic dissemination in urinary bladder cancer (the same patient as in Fig. 7.).

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Fig. 0: CT features of ovarian cancer with multiple hematogenous subcutaneous, intraperitoneal, retroperitoneal, and intramuscular deposits.

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Fig. 0: Ultrasound features of invasive ovarian cancer tended to hematogenous spread (the patient in Fig. 9.).

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Fig. 0: Ultrasound features of ovarian cancer with hematogenous disseminations.

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Fig. 0: Peritoneal carcinomatosis with loculated fluid collections (ascites) on CT.

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**Fig. 0:** Peritoneal carcinomatosis with generalized ascites on CT.

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Fig. 0: Peritoneal carcinomatosis with loculated collection (ascites)- ultrasound view.

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Fig. 0: Peritoneal carcinomatosis with generalized ascites - ultrasound feature.

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Fig. 0: Subphrenic (parietal) nodular deposits surrounded with ascites.

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Fig. 0: Heterodense metastatic lesions in the large omentum (stomach cancer origin) with deposits in the liver. It have to be noted post contrast enhancement of peritoneal thickening and deposits.

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Fig. 0: Heterodense lesions discovered in omental sac and in peritoneal cave, ovarian cancer origin.

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**Fig. 0:** Hetero-hypo echoic lesion surrounded with small collection of fluid demonstrates tumor mass with thickened poorly defined bowel wall, colon cancer origin - ultrasound feature.

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Fig. 0: Hypo echoic thickened abdominal wall with attached poorly defined bowel walls, ovarian cancer origin.

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**Fig. 0:** Hypo echoic poorly defined lesions, near the anterior abdominal wall, pancreas cancer origin.

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**Fig. 0:** "Omental cake" ovarian cancer origin with CT signs of peritoneal thickening and post-contrast enhancement.

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Fig. 0: "Omental cake" with CT signs of post-contrast peritoneal enhancement and small collections of ascites.

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**Fig. 0:** "Omental cake" as a solid hetero-hyper echoic lesion (stomach cancer origin) imbibed transversal colon and attached to anterior abdominal wall - ultrasound feature.

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**Fig. 0:** "Omental cake" by ultrasound, as solid hypo echoic lesion (ovarian cancer origin) imbibed bowel walls and attached to anterior abdominal wall.

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Fig. 0: Misty mesentery with ascites, unclear contours, cover up lymph nodes and deposits - CT.

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**Fig. 0:** Misty mesentery on coronal MPR cover up lymph nodes and deposits.

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Fig. 0: Small nodular parietal deposit attached to anterior abdominal wall.

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Fig. 0: Abdominal peritoneal solitary nodular deposits in large bowel disease.

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Fig. 0: Ovarian carcinoma with peritoneal deposits, without ascites.

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Fig. 0: Ovarian carcinoma with peritoneal deposits, without ascites.

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Fig. 0: Nodular deposit visualized by ultrasound, characterized by size (more than 2 cm), colon cancer origin.

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**Fig. 0:** Nodular deposits visualized by ultrasound, characteristic localization of stomach cancer origin.

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Fig. 0: Nodular deposits visualized by ultrasound near the abdominal wall, pancreas cancer origin.

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Fig. 0: A large solid omental deposit, hypoechoic on ultrasound feature - metastasis of ovarian carcinoma.

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Fig. 0: A large solid omental deposit in the same patients, as in Fig. 35., with post contrast enhancement (CT examination) - metastasis of ovarian carcinoma.

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Fig. 0: Nodular lesion on ultrasound - metastasis of pancreatic carcinoma

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**Fig. 0:** Nodular omental disease - metastases of pancreatic carcinoma

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**Fig. 0:** Heteroechoic solid lesion adjacent to the anterior abdominal wall - stomach cancer origin.

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Fig. 0: Nodular omental lesion, adjacent to the anterior abdominal wall - in same patients with stomach cancer.

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**Fig. 0:** Metastatic ovarian cancer with subcutaneous deposits and deposits of anterior abdominal wall - ultrasound features.

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Fig. 0: Metastatic ovarian cancer with subcutaneous deposits and deposits of anterior abdominal wall - CT examination of patient in Fig. 41.

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**Fig. 0:** Nodular metastatic lesions deeper in the peritoneal cavity - metastases of colon carcinoma - US feature.

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Fig. 0: Nodular metastatic lesions - metastases of colon carcinoma - CT.

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Fig. 0: Omental and peritoneal nodular deposits, heteroechoic on ultrasound, ovarian cancer origin.

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Fig. 0: Omental and peritoneal nodular deposits, with high post-contrast CT enhancement, localized adjacent to the right hemidiaphragm and near the left anterior abdominal wall - metastases of ovarian carcinoma.

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**Fig. 0:** Omental deposits discovered by ultrasound examination were similar to lump nodes, stomach cancer origin.

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Fig. 0: In the same patient with stomach cancer, omental deposits were similar to lump nodes - CT.

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Fig. 0: Nodular deposits with distension of bowel loops and suspected signs of sub occlusion (colon cancer origin).

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Fig. 0: Nodular deposits with distension of bowel loops and evident signs of sub occlusion (colon cancer origin).

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**Fig. 0:** Ultrasound feature of extremely distended bowel loops, suspected subocclusion and with the sign of "colon look like" intestinal loops.

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Fig. 0: Partially distended bowel loops with peritoneal implants - ultrasound feature.

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Fig. 0: Extremely distended bowel loops with small liquid collections (ascites) - ultrasound feature.

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Fig. 0: Nodular deposits with distension of bowel loops and nodular deposit and suspected signs of sub occlusion (colon cancer origin).

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Fig. 0: The best Predictive Positive value (PPV) of 92% was shown for US features of sub-occlusions.

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**Fig. 0:** The best Predictive Positive value (PPV) of 92% for US features were shown for sub-occlusions.

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Fig. 0: The best Predictive Positive value of CT findings were found depending on tumor mass size (96.8%).

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**Fig. 0:** The best Predictive Positive value of CT findings were found also depending on localization (89, 6%) and sub-occlusions (83,3%).

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**Fig. 0:** Great tumor mass in pelvis invaded ovaries and uterus and with extensive locoregional spread of disease. The best Predictive Positive value of CT findings were found depending on tumor mass size (96.8%).

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**Fig. 0:** The sensitivity of ultrasound characteristics in peritoneal carcinomatosis (table and graphic reports).

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**Fig. 0:** The accuracy of ultrasound characteristics in peritoneal carcinomatosis (table and graphic reports).

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**Fig. 0:** The sensitivity of CT characteristics in peritoneal carcinomatosis (table and graphic reports).

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**Fig. 0:** The accuracy of CT characteristics in peritoneal carcinomatosis, (table and graphic reports).

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Conclusion

In conclusion ultrasound diagnostic value in peritoneal malignant emergencies is not very significant, but the signs of distending, undefined bowel loops, attached to abdominal wall, and the suspected signs of sub occlusion, with intrabdominal solid masses, could confirm with the significance the presence of peritoneal deposits or peritoneal carcinomatosis.

MSCT in our investigation results with the right criteria in diagnostic of peritoneal malignant emergencies, especially looking at the size, localization, the presence of distending bowel loops with sub occlusions, and also with signs of undefined solid masses, or the masses in block, without clear contours, as well as with presence of nodular deposits near the abdominal wall or attached to parietal peritoneum.

However diagnostic US criteria of peritoneal deposits, compared with CT, upgrade the quality of practice and are low cost effectiveness.
References:


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