Tumors that invade the inferior vena cava: An illustrative review of the main imaging features on computed tomography and magnetic resonance

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Abstract
The objective of this article is to describe the multiple entities that can affect and invade the inferior vena cava. Among these we can list not only benign entities, but with an aggressive behavior, but also malignancies that originate in organs adjacent to this vascular structure or therein such as leiomyosarcoma. In this review different examples on computed tomography and magnetic resonance with cases of angiomyolipoma, pheochromocytoma, adrenal carcinoma, renal cell carcinoma, hepatocellular carcinoma, retroperitoneal sarcoma and leiomyosarcoma originating in the inferior vena cava, are presented. In addition, situations that may lead to misdiagnosis such as flow artifacts and pseudolipoma are presented.

Keywords: CT, Inferior vena cava, Radiology, Tumors.

Introduction
Currently there is a significant increase in the acquisition of images for diagnostic purposes. The use of computed tomography (CT) and magnetic resonance imaging (MRI) are becoming more frequent and thus the detection of abnormalities of the inferior vena cava (IVC) has become more common, so the radiologist should be familiarized with the various entities that may affect it. The development of new imaging modalities has made it possible to improve the processes of detection, staging and monitoring of neoplasms originating in the surrounding structures, as well as provide information to clinical and surgical oncologists regarding the local and distant extension of the various types of abdominal tumors. For its part, the affection of the IVC may be due basically to 2 types. The first corresponds to a tumoral thrombus occupying the vessel lumen and the second to the invasion and infiltration as such of the vascular wall. This differentiation is essential when making surgical decisions and defining the therapeutic management. Thus, the intraluminal extension of the tumor may be susceptible for complete resection and obtain healing results if other secondary locations or invasion of adjacent organs is ruled out(1-3).

This pictographic review aims to expose the main entities that can invade or infiltrate this structure. Among these several of benign strain that can adopt an aggressive behavior and invade neighboring vascular structures, including the IVC, and on the other hand, malignant neoplastic entities that spread through it via endovascular areas or by direct local extension. In addition, we mention the various pseudo lesions affecting the IVC, the majority benign and which can lead to errors when interpreting the images.

Renal angiomyolipoma
This is a rare tumor of mesenchymal origin, with a structure composed of vascular, smooth muscle and fatty elements. It presents sporadically or in association with tuberous sclerosis. By nature, the vast majority is benign, however it can have an aggressive evolution invading the renal vein, IVC and even the right atrium(4,5) (Figures 1 and 2).

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Another tumor that can invade the IVC, both in its malignant and benign versions is the pheochromocytoma, which corresponds to a rare tumor composed of chromaffin cells originating from neuroectodermal tissue of the adrenal medulla and which can be a producer of catecholamines. Traditionally these have been referred to as “the 10 percent” tumor, because this percentage is applicable to various features. Thus, 10% are extra-adrenal, 10% malignant and 10% are associated with particular syndromes such as multiple endocrine neoplasia IIA and III, Von Hippel Lindau syndrome and neurofibromatosis(6).

Pheochromocytomas may present a locally aggressive behaviour, invading structures such as the renal capsule or the IVC (Figures 3 and 4).

Some authors have reported that the invasion of the underlying venous structures can occur between 4-10%(8,9). This information, at the moment of issuing the report, is of fundamental importance because some groups have reported that it affects patient survival and also determines the surgical technique (Figures 5 and 6).

In the particular case of renal cell carcinoma, invasion of the vena cava by tumor thrombus does not contraindicate surgical resection, with the possibility existing of resecting the tumoral thrombus(3). On the other hand, it is important to confirm the extension of the thrombus, either infra or supra-diaphragmatic, the latter being the worst prognosis, and also if the vascular wall is infiltrated, which involves resecting the vascular segment block, with the respective implications both in the immediate postsurgical outcome as well as long term(3,9).

Renal cell carcinoma

This corresponds to the most common kidney cancer subtype and represents about 2% of malignant cancers affecting adults(7). Usually renal cell carcinoma (RCC) has an expansive growth and can invade or displace the capsule. If its extension is deep, it can invade the pyelocalyceal system or the vessels of the renal hilum.

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Adrenal carcinoma

This is a malignant neoplasm with a reported prevalence of 0.5 - 2 cases per 1,000,000 patients. 62% of patients have functional tumors that could cause Cushing syndrome, virilization or feminization (Figures 7 and 8).

Hepatocellular carcinoma

Hepatocellular carcinoma usually invades the portal venous system, but the invasion of the inferior vena cava and the suprahepatics may occur in up to 4% of patients. The characteristic finding is the dilation of the veins involved and the presence of intraluminal thrombus that enhances after contrast administration. The presence of this type of condition predisposes to the development of distant metastases and worsens the prognosis, decreasing survival to only 1 to 4 months (Figure 9). More so, for some authors, the invasion of the IVC is considered an exclusion criterion for hepatocarcinoma surgical resection.

Leiomyosarcoma of the inferior vena cava

Leiomyosarcoma is the primary malignant tumor that most often affects the IVC, and it originates from the parietal muscle cells of the vessel. Approximately 74% of leiomyosarcomas of the IVC affect women between 40 and 60 years of age. This neoplasm may depend on the lower middle or upper third of the IVC and have an intra or extraluminal component, featuring in two thirds of cases a predominantly extraluminal growth, hindering the diagnosis of this entity because it simulates a mass with its isocenter located in the retroperitoneum and which seems to invade the IVC, when in fact it originates therein. This aspect is very important, since leiomyosarcomas arising in the IVC have a better prognosis with surgery and complete resection of the vein, unlike what might happen with other tumors, in which only radio or chemotherapy could be offered. On CT it appears as a solid mass with calcifications and may have hemorrhagic or necrotic areas when it becomes bigger (Figure 10). On MR it may have a low sign in T1-weighted sequences and intermediate or high sign in T2-weighted sequences, which depend mainly on the size of the necrotic component. To determine whether the lesion emerges from the IVC, the most frequent sign is the imperceptibility of the venous structure as such, followed by the presence of intraluminal tumor. In addition to having its origin in the IVC, leiomyosarcoma can be of retroperitoneal origin and secondarily invade the vena cava, as set forth in Figure 11.

Occasionally, other malignant entities such as pancreatic adenocarcinoma, Wilms tumor and metastasis in retroperitoneal lymph nodes may extend to the IVC. For example, in the case of the metastatic lymph nodes, some studies have shown that between 3-11% of those derived from a non-seminoma type testicular carcinoma could invade the IVC.

Finally, it is important to note certain entities that can simulate lesions of the IVC and lead to errors, especially when associated with neoplasias, causing the radiologist to overestimate a false intravascular affection.
This is a rare pseudo-lesion in which the periarterial adipose tissue located on the caudate lobe appears to extend into the IVC. The best way to determine if it actually is real lesion or not, is by observing the coronal or sagittal plane reconstructions (Figure 12).

Pseudolipoma

This is a rare pseudo-lesion in which the periarterial adipose tissue located on the caudate lobe appears to extend into the IVC. The best way to determine if it actually is real lesion or not, is by observing the coronal or sagittal plane reconstructions (Figure 12).

Flow artifacts

Flow artifacts are the most frequent entities that can simulate an IVC lesion, caused by the blending of the contrasted venous blood from the renal veins when mixed with that which is not contrasted that comes from the lower extremities. It can also be seen in situations where low amounts of contrast are used, in cases of right heart failure and in patients where the acquisition sweep is performed at an early portal phase (Figure 13).

Venous thrombosis

The most common filling defect in the vena cava is thrombosis, which occurs most frequently in users of oral contraceptives, patients with antiphospholipid syndrome, vasculitis and various coagulopathies. The use of filters also determines the presence of endoluminal thrombus. It is important to mention that paraneoplastic hypercoagulable states can influence the development of thrombi, which are difficult to differentiate from tumor thrombus. One way to differentiate them is by identifying the intraluminal mass enhancement after contrast administration.

Conclusion

There are multiple entities that can affect the IVC and they represent a challenge for the current radiologist. This article describes a variety of diseases that can affect it. In all of them, the images allow adequate evaluation, thus contributing to decision-making.

Conflict of interests

The authors declare no conflict of interest.

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