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Chapter

Radioimaging Diagnosis of Vaterian Ampulloma: Technique, Semiology, and Differential Diagnosis - Review

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Abstract

The lining of the Vater papilla represents a complex set of folds of the mucous membrane which acts as an anti-reflux valve and participates in regulating the flow in pancreatic and biliary secretion. The constitutive smooth muscles of the Oddi sphincter differ both anatomically and especially embryologically from the parietal duodenal muscles. This is one of the reasons why some authors believe that the vaterian ampulloma is a distinct oncologic entity from the rest of the duodenal or pancreatic primitive neoplasia. The variations of the implantation manner in the papilla of the common bile duct and pancreatic one simultaneously determine different ways of surgical approach of malignancies of this region. Radioimaging diagnostic methods in suspected vaterian ampulloma require a more special technique. The purpose of this paper is to determine the potential semiological, radiological, and imaging characteristics that will allow a diagnosis of vaterian ampulloma, considering that the surgical therapy, as well as the survival rate in patients, is different from the other neoplasm of the region.

Keywords: vaterian ampulloma, duodenum, barium meal, duodenography, computed tomography, MRI, vaterian ampulloma

1. Introduction

The region of the ampulla of Vater is an anatomical and functional complex, a separate entity, mainly comprising the biliopancreaticoduodenal confluence area. The ampulla territory includes in its structure the terminal portion of the choledoch, including the Oddi sphincter and the main duct of Wirsung, forming the papilla at the duodenal level. In 85% of cases, the openings of the main bile duct and the pancreatic canal are common. The terminal choledoch, after crossing the duodenal wall, next to the duct of Wirsung, opens in the ampulla of Vater. The choledoch implants in the papilla is variable. In most cases, the choledoch has a tangential implantation through the duodenal wall, reaching the level of the ampulla, the choledoch ends differently, either with a highly developed sphincter in the case of a small ampulla or with a much less developed sphincter in the case of a well-highlighted ampulla [1].

The localization of the papilla at the duodenum level is in most cases on the medial contour of the descending duodenum, at the junction of the middle third with the lower third, but ectopic positions of the papilla are known, cranial at 1–2 cm below the bulb level, or caudal at the lower duodenal knee level [1].

A special place is occupied by the cancers of the ampulla of Vater, which are distinct entities, separate from those of the duodenum, although the anatomical location of the ampulla of Vater is at the level of the descending duodenum, due to their embryological origins and the different histological structures [1].

Neoplasms of the vaterian region, also known as vaterian ampulloma, may have as a starting point the cylindrical choledochal epithelium, the Wirsungian cubic epithelium, or the glandular epithelium of the papilla. Due to their origin in an epithelial type tissue structure, histopathologically these tumors are adenocarcinomas [1].

2. Radioimaging techniques of the duodenopancreatic region

The involvement of the duodenum in the neighboring tumor pathology is explained primarily by the multitude of anatomical direct relationships that this organ has with the pancreas, liver, right kidney, colonic hepatic angle, etc.

Neoplasms of the vicinity that have been shown to be invasive in the duodenum are pancreatic tumors, regardless of the segment of this organ, hepatomas, gallbladder cancers, cholangiocarcinomas, malignancies of the right kidney, and colonic, retroperitoneal, as well as gastric duodenal lymphoma. Of these, the most common are the pancreatic neoplasms and the vaterian ampullomas [1].

From our experience, duodenal neoplasms can reach 13% of the total number of neoplasms of the pancreatic-duodenal region, most common being the invasive pancreatic cancer in the duodenum, with a percentage reaching up to 65%, followed by the vaterian ampullomas with a frequency of over 10% [1].

Talamini et al. [2] considers in a study conducted over a 28-year period that ampullary adenocarcinomas are the second most common malignancy in the periampullary region. In the present work, the vaterian ampullomas are in second place by frequency, after the pancreatic neoplasms, but in a ratio equal to the duodenal malignancies themselves.

The objectives of the radio-imagistic explorations in the vaterian ampulloma are:

- Detection of the tumor lesion, providing information on the location, shape, dimensions, and contours of the space replacement process, as well as on the presence of any ulcerations or fistulas and the degree of lumen stenosis

- The state of the duodenal mucosa, insisting on the morphofunctional and autoplastic changes

- Modifications of the duodenal papilla

- Changes in size of the duodenal wall

- Extension of the ampullary lesion in the periduodenal space

- The existence of modifications of the parenchymatous organs or segments of the digestive tract potentially involved in the mechanisms of tumor onset or the degree of tumor invasion in the neighboring organs

- The existence of possible subdiaphragmatic adenopathies

2.1 Radiological exploration

2.1.1 Conventional radiological examination: barium meal

By its anatomical location, any lesion at the level of the ampulla of Vater requires the radiological study of the duodenal framework, especially the descending duodenum.

Examination of the duodenum follows that of the stomach, which is why some aspects are difficult to highlight or elude the examiner due to technical defects or because he is distracted by the presence of other concomitant or associated lesions of the esophagus or stomach.

2.1.1.1 Simple contrast technique

The technique of examining the duodenum using simple contrast is that used in routine examination, following that of the esophagus and the stomach [1]. During this examination the patient ingests 240–360 ml of barium sulfate suspension in water, concentration 30–40%. It is preferable for the contrast agent to have small particles with a high dispersion degree of 4000–6000 particles/cm^2. For a better adhesion of the contrast agent to the mucosal folds, it is recommended to associate a homogenizing agent such as methyl cellulose in the barium sulfate suspension.

Preparation of the patient in the event of a suspected vaterian ampulloma should be done with great care, including an adequate diet, avoiding fermentable foods, long-molecule cellulose, and excess lipids, prohibiting any food intake 6–8 hours before examination, or secretion evacuation if the existence of a stenosis is a certainty. In order not to modify the functional duodenal mechano-secretory behavior, it is advisable to avoid the administration of drugs with implication in the duodenopancreatic physiology.

In this method of examination, the bulb and the rest of the duodenal frame are filled with contrast agent due to gravity and normal peristaltic movements of the stomach, the patient being in orthostatism, ventral decubitus, or right lateral decubitus.

The technique of simple contrast duodenal exploration is a routine examination. It can be performed at any radiology office. However, the method also has drawbacks, the main ones being the overlap of the antrum and the sometimes-insufficient distension of the duodenum.

2.1.1.2 Double-contrast technique

This technique can be mainly achieved in two ways [1]:

a. Double-contrast hypotonic duodenography

b. Probe duodenography

2.1.1.2.1 Double-contrast hypotonic duodenography

Evaluation of the duodenum in double contrast may be part of the standard double contrast of the upper gastrointestinal tract. The examination starts with the carrying out of a seriography after ingesting a single barium swallow that allows a good lining of the digestive mucosa; this represents the mucographic time. At the same time, the exact position of the different portions of the gastric segment is noted.

The double-contrast hypotonic duodenography can be obtained using two methods: the double-contrast method performed during the eso-gastro-duodenal examination, using glucagon and a gaseous potion as a pharmacodynamics, or the hypotonic duodenography in which the patient is given an antispastic after administration of the contrast agent.

In the first method, the double-contrast phase can be obtained by inducing a short-term hypotonia by injecting 0.1 mg of glucagon IV at the beginning of the examination, after which the patient ingests the gaseous agent, respectively, a mixture of citric acid and sodium bicarbonate, with 10 ml of water and high-density barium sulfate, of about 200–250 wt/vol%. After 5–10 min, during which the esophagus and stomach are examined, the hypotonic effect of the glucagon is finished so that the air and barium pass easily through the pylorus and reach the duodenum. The positioning of the patient in ventral and left posterior oblique decubitus fills the duodenal bulb with high-density barium. The compression performed in ventral decubitus is not as useful as in simple contrast due to the increased barium density. We can obtain a series of double-contrast images of both the bulb and duodenal frame in the right anterior oblique position after the patient ingests 240 ml of low-density barium suspension.

The method has maximum reliability for examining the stomach, duodenal bulb, and possibly the descending duodenum. It has the disadvantage that it does not allow a good assessment of the state of the duodenal mucosa, and the overlaps of the antral portion cannot always be excluded. Also, the two fractions of barium suspension can be mixed, which may induce interpretation errors.

In the second method, the exploration is required to be carried out quickly; the patient should swallow 100–150 ml of barium sulfate suspension. The patient is placed in dorsal decubitus, then the antispastic is injected, after which the subject is immediately repositioned in the right lateral decubitus, a position in which he ingests the effervescent potion through a pipette or cannula. The contrast agent enters the duodenum which is already in hypotonic state. The duodenum in repletion and hypotonia is radiographed in this position and in several incidences in left posterior oblique position. The duodenal distension fades in dorsal decubitus and the root of the mesentery no longer ensuring its compression on D3. An accumulation of contrast agents is observed in the bulb. In this situation it is sufficient to raise the table by 30° in order to evacuate it and to be able to carry out the correct seriographies on the duodenum, especially the descending portion and the bulb, which, due to the hypotony, expands with the gas released by the effervescent potion.

There is also a method that can prevent overlapping of the gastric antral. This consists of introducing an Einhorn probe into the duodenum and through it 10 ml of xylin, with high viscosity administered at body temperature, which can achieve a hypotonia of the duodenum after a few minutes. Instead of xylin, scobutil can be used, administered intravenously. The hypotonic effect occurs in about 15–30 min. Barium sulfate suspension administration on the probe allows the duodenal framework to be completely opacified.

The method also has disadvantages. Antispasmodics alter the kinetics, tonicity, and duodenal secretion. During this time, due to the induced changes, the duodenal stasis is accentuated. For this reason, the low-density barium sulfate suspension is mixed with the stasis liquid, and if we do not use a homogenizing agent, bubbles may appear at the air-liquid interface that can fix themselves on the mucous folds, leading to an erroneous diagnosis. The method gives exclusively morphological information which means an incomplete radiological diagnosis. Due to hypotonia and hypokinesia, any stiffness and the study of autoplasty cannot be properly appreciated.

2.1.1.2.2 Selective duodenography or probe duodenography

This method is used when the radiologist is interested in studying the duodenal framework or when, following previous examinations, the suspicion of a strictly localized lesion at this level is raised.

An enteral probe is used to perform this technique. The probe is introduced nasally or orally after the pharyngeal mucosa is embrocated or anesthetic solution is gargled. The distal end of the probe should reach the mid-level of D2; insertion of the probe into the stomach is done with the patient in a seated position, after which the patient lies in a right lateral decubitus and the probe is passed through the pylorus. To avoid coiling the probe, it is good to use either a probe weighted at the end or a metallic, soft, and flexible guide. The positioning of the probe will be done under radioscopic control. Then the duodenum is aspirated, after which the barium suspension is introduced under pressure, in a volume of about 30–50 ml. The suspension of barium sulfate must be fluid, homogeneous, and very adherent. It is indicated that the barium sulfate has a high dispersion degree and the suspension contains a methyl cellulose-type surfactant. Double contrast is obtained by blowing about 80–100 cm^3 of air into the duodenum. The insufflation is gradual, under radioscopic control during examination.

The examination is performed in several positions and incidences, being mandatory to start from dorsal and right oblique anterior decubitus, continuing with the ventral and oblique posterior left decubitus, performing serial X-rays. Highlighting any anomalies requires X-rays of different incidences and intermediate positions, being able to better highlight the lesion.

The results are good, but they require a perfect knowledge of the anatomy of the region and the normal radiological aspect, since it differs from the known radiological anatomy.

The main advantage of the method is that it is possible to avoid overlaps with other segments of the digestive tract, especially with the gastric antrum. Also, by this method, small lesions of the mucosa can be detected, which can elude the examiner in simple contrast or in double contrast performed during the eso-gastro-duodenal examination. Antispastic substances that modify normal duodenal tonicity and kinetics and which modify duodenal secretion are not used. In this way the examination can also provide functional data of the investigated segment.

The examination is unpleasant for the patient due to the need to introduce the probe; therefore it is advisable that the examination be preceded by a brief discussion with the subject, in which the technique and the need for the examination will be explained to him. The crossing of the pylorus cannot always be realized; at position changes, a withdrawal of the probe into the stomach can occur, an incident that can also occur at a sharp intake of breath. This can be avoided if the examination is performed using a probe with a balloon at the end, which will set it to the desired level. The advantage of using such a probe is to prevent airflow back into the gastric antrum.

The time required for the examination is long. The technique is not of first intention, usually being performed only when there are clear clinical indications about the presence of a space replacement process.

The radiological techniques described can assess the overall duodenal morphology. Under distension and hypotony, the duodenal frame as a whole appears slightly enlarged. The examination allows to identify the duodenal anatomical segments and their possible anatomical variants (reverse V duodenum, mobile duodenum, small duodenal frame, surrounding the bulb, as in the case of gastric ptosis).

On the postero-external border of the descending duodenum, it is possible to highlight a possible imprint, due to the direct relations with the right kidney at this level.

Duodenal distension is exercised up to the level of its horizontal portion, immediately after the lower knee, when the examination is performed in ventral and oblique posterior left decubitus, being determined by the compression of the mesenter's root over D3; in dorsal decubitus the compression is attenuated.

In dorsal decubitus the large papilla is visualized as a round-oval or oval transparency, contoured by the contrast substance. This area corresponds to the intramural pathway of the choledoch. The surrounding, well-visualized folds can converge into a single longitudinal fold or a bifid fold. The small papilla is rarely seen as a round lacunar image, with a diameter of about 5 mm, located cranially and medially to the large papilla.

In lateral decubitus, the longitudinal fold is highlighted on the endoluminal face, and the external duodenal contour becomes rectilinear due to the distension that erases the connivent valves. At the place of formation of the longitudinal fold, toward the tuber, a notch can be distinguished, which corresponds to the choledochian sphincter at this level. The small papilla is sometimes viewed as a notch located cranially to the large papilla.

Conventional radiological techniques represent at this time methods that are really historical, computed tomography replacing almost all of them.

2.1.2 Computed tomography

Technological progress (much shorter scanning time, better spatial resolution) and the new adapted examination protocols allow accurate study of the digestive wall and extra-parietal lesion extension [1, 3–8].

The main problem is obtaining an optimal distension of the duodenum in order to be able to correctly estimate the thickness of its wall, which is the most important computed tomography criterion of normality.

The duodenum is the most difficult region to examine due to the difficulty of obtaining adequate opacity, this being determined by the accelerated transport of water into the lumen, the water that dilutes the contrast agent.

Therefore, for the study of the duodenum, in fact of the entire upper digestive floor, the CT scan must be preceded by the ingestion of 600 ml of iodinated, water-soluble contrast substance, in a dilution of 2–3% approx. 5–10 min beforehand. IV antispastics can also be associated, which allow for a good study of the duodenal framework and the dissociation of the pancreas head. The exclusive use of air distension, as well as the use of simple water in combination with gastroduodenal hypotonia, increases the quality of parietography. The normal thickness of the duodenal wall is considered to be 3–4 mm.

The use of antispasmodics administered IV may diminish the artifacts generated by peristalsis, but due to the current ability to use a scanning time of less than 5 seconds, it is no longer of interest.

The intravenous administration of the iodinated contrast agent should be systematic for assessing the iodophilia of the lesion and for studying the relationships with the neighboring structures. It is also used to assess the extent of the tumor lesion, by determining the metastases, as well as to assess the existence of any abnormalities in the parenchymal organs, in relation to the duodenal disease or simultaneous with it.

In view of the frequent involvement of the duodenum in the neighboring tumors, especially those in the pancreas, in the vaterian ampulloma, etc., performing the computed tomographic examination both native and with contrast agent becomes almost obligatory. Thus, computed tomography becomes the essential method of establishing the starting point in duodenal tumor determinations, at the same time achieving the pre-therapeutic balance of the lesion extension.

The administration of the intravenous contrast substance allows at the same time to opacify the vascular landmarks of this region, particularly the renal vein, inferior vena cava, as well as of the superior splenic and mesenteric vessels. The possibility of conducting the spiral computed tomographic examination gives almost overlapping information with the angiographic examination.

The acquisition is made through contiguous sections, 5 mm thick, but 3 mm sections can be used to allow analysis of small organs or to obtain details on the lesion.

The patient is initially placed in dorsal decubitus. The computed tomographic examination can be complemented, depending on the needs, with sections performed in ventral decubitus, lateral decubitus, sections that highlight the digestive connection of large tumor masses, and their dissociation from the adjacent viscera.

The use of some image processing techniques allows biplane or spatial reconstruction of the bile ducts and the duct of Wirsung and is usually used to detect lesions of distal bile ducts and in the vaterian ampulloma.

2.2 Imaging explorations

2.2.1 Ultrasound

Ultrasonography as an imaging exploration of the duodenum is not a primary intention technique [1, 9]. It can be performed transabdominally—routine examination in which the primary information is related to the pathology of the parenchymal organs—and echoendoscopy, a method with maximum reliability on the pathology of the duodenal wall and the eventual differential diagnosis between primitive duodenal lesions/invasion by contiguity.

If the first technique of ultrasonographic exploration has a general addressability and accessibility, not requiring a special training of the patient, the second technique requires special equipment and a special skillset, being used especially by the doctors performing endoscopy, as a complement to a routine endoscopic examination.

Transparietal ultrasound can reveal changes of the duodenal peristaltic, duodenal stasis, or parietal duodenal infiltration. Complementing the examination with the Doppler technique may bring additional information to the duodenal tumor pathology. Probes of at least 5 MHz should be used for better lesion detection.

Ultrasound examination of the pancreas and distal bile ducts is the primary method for any suspected tumor pathology.

The specificity and sensitivity of the method depend on the quality of the equipment, but in particular, on the experience of the one using the method.

2.2.2 MRI

MRI scanning is not a primary imaging technique for patients with suspected tumor pathology of the duodenum-pancreatic region [1, 10–17]. The possibility of clearly highlighting soft structures and multiplane images makes this method superior to computer tomographic exploration. Magnetic resonance highlights both the duodenal wall and the intraluminal duodenal content.

The body antenna is most commonly used. The spin echo sequences are constituted as reference sequences. T1-weighted sequences with short TR and TE allow excellent spatial resolution, providing the best morphological information of abdominal viscera.

T2-weighted sequences with long TR and TE have a good resolution in contrast and allow a more reliable tissue study. Given the relatively long acquisition time, at least 3 min, FLASH or SPGR gradient echo sequences are used more frequently, although they have a lower signal-to-noise ratio.

The use of fat saturation sequences reduces respiratory and structural artifacts but has a longer acquisition time.

For a complete study, it is absolutely necessary to use sequences specific to the study of vessels.

In case of suspicion of an ampullary tumor, MRCP is mandatory. In the last three decades, this technique has become absolutely necessary in the diagnosis of a biliary duct obstruction, obstruction which is caused at the right level by an ampullary tumor. MRCP is a diagnostic method, while ERCP remained a rather interventional method. T2 hyperintensive sequences are used, which make the content of both biliary and Wirsung ducts white in contrast to the rest of the structures. Sequences with thin sections (3–5 mm), which have the purpose of an MIP type reconstruction, and sequences with thick sections (30–50 mm), which have a short acquisition time (<5 s) and which are performed in multiple planes, are used. The acquisitions are made in the coronal and oblique coronal plane. If we refer strictly to MRCP, the administration of the contrast agent is not obligatory, but in the case of the ampullary tumors, this is a complementary sequence that is associated with the abdominal MRI scan. The MRCP highlights the contents and implicitly the size of the bile ducts and the duct of Wirsung, but does not give details on their wall, which was done by an abdominal MRI scan.

However, with MRCP you can administer negative oral contrast agent that reduces the hypersignal of gastric and intestinal fluids, thus increasing the contrast of the contents of the bile ducts and the duct of Wirsung.

In addition, the MRCP technique can provide information on the pancreatic function. This is achieved by the intravenous administration of secretin which has the role of increasing the pancreatic exocrine function, so it will increase the flow and quantity of pancreatic juice, and implicitly it will expand to the maximum the pancreatic ducts, thus being able to highlight both the main duct and the secondary ones.

The axial plane examination constitutes the reference sequences of the examination. In order to specify the exact anatomical reports or for the study of the vessels, frontal and coronal acquisitions are also made.

The mucosal study is performed using water per os or more reliably through the probe. The study of parietal changes requires sequences with paramagnetic contrast products.

The MR exploration, due to the possibilities of acquisition, processing, and reconstruction of the images, allows the study of the biliary ducts, having major importance in the tumor pathology of the duodenopancreatic region and the study dedicated to the vessels related to this region.

3. Semiology of ampulla of Vater neoplasms

The histological structure comprises the tunics of the duodenal wall but also a separate muscular entity—the Oddi sphincter [1]. In terms of structure, the smooth musculature of the Oddi sphincter differs both anatomically and embryologically from the surrounding duodenal musculature. Its mechanical and electrical activity is independent and different from that of the duodenal muscle, but it is integrated into myogenic, regulating mechanisms through innervation and hormonal activity.

The mucus of the Vater papilla forms a complicated system of folds whose main function is the creation of "valves" with anti-reflux role, especially for biliary drainage. The ampulla of Vater is visible during the radiological examination in double contrast of the duodenum, being recognizable due to the presence of a superior fold and the longitudinal fold, located on the posteromedial face of the descending duodenum. Frequently at this level, there are two oblique folds. In conventional radiological exploration, in simple contrast, visualization of the papilla is much more difficult.

These are briefly some of the anatomical, functional, and embryological arguments that cause the tumor pathology of the ampulla of Vater to be treated separately from that of the duodenum, although the location of the Vater papilla is at the level of the descending duodenum, approximately in the middle of it.

These considerations have a very important practical substrate. According to Dudiak et al. [7], there is a direct interrelation between the anatomy and the embryology of the papilla and the radiological and endoscopic exploration possibilities, but especially in interventional radiology and endoscopy.

3.1 Radioimaging changes found in ampulla of Vater neoplasms

Regardless of the radioimaging method used, in the case of neoplasms of the ampulla of Vater, several signs that can guide the diagnosis can be highlighted (**Figure 1**).

Computed tomography and magnetic resonance imaging are particularly reliable in diagnosing cancers of the ampulla of Vater (**Figures 2** and **3**).

Next we tried an analysis of these signs, direct or indirect, which alone or associated would help the radiologist to diagnose the lesion as accurately as possible.

3.2 The lacuna

The classical radiological appearance of the ampullar neoplasm consists of a lacunar image located in the region of the ampulla of Vater, which can be located intraluminally or marginally, on the internal contour of the second portion of the duodenum. This radiological change is also mentioned as a radiological sign of probability of a vaterian ampulloma by Caroli et al. [18].

The lacuna, as an elementary change in the radiological diagnosis of the ampulla, has lost its importance with the advent of other techniques of radioimaging investigation. In view of its existence, relatively frequently encountered today in standard radiological exploration protocols, we introduced the analysis of this radiological sign in this study as well.

Figure 1.
Vaterian ampulloma: Conventional exploration.

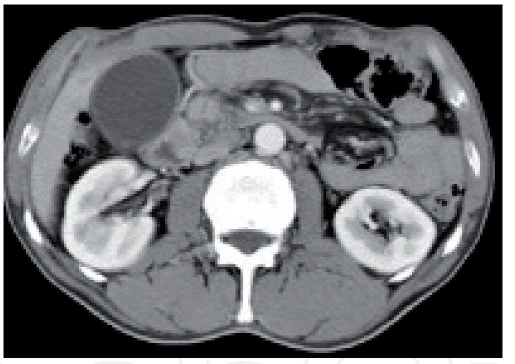

Figure 2.
Vaterian ampulloma: CT exploration.

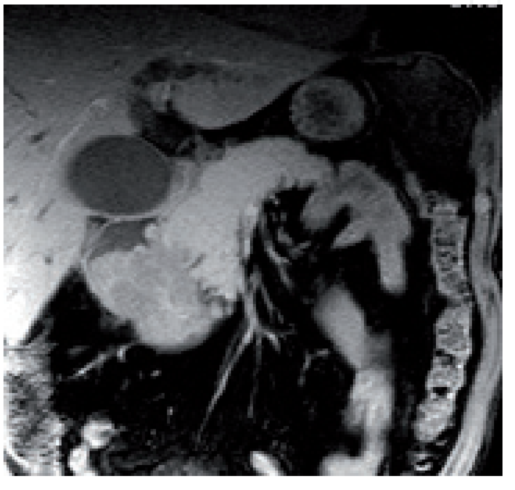

Figure 3.
Vaterian ampulloma: MRI exploration.

The lacuna can be highlighted in a percentage of less than 40% of the total cases of malignancies of the pancreatic-duodenal region [1] (**Figure 4**).

The standardized criteria of malignancy of a lacuna considers that it must have an irregular and erased contour; it must interrupt the folds, due to peritumoral malignant infiltration, coexisting with the presence of possible superficial ulcerations; and, in principle, it is larger than 2–3 cm. Although it is known that ampullary carcinomas do not reach overly large sizes until the moment of diagnosis, due to the relatively rapid installation of jaundice, the specialized literature attests the presence of areas of neoplastic cells in the structure of a vaterian adenoma, even of very small dimensions.

Because of this, but also due to the fact that a conventional radiological examination, no matter how well performed, cannot accomplish the benign-malignant differentiation in the case of ampullary tumors, we consider that only the contours and dimensions of the ampullae should be analyzed.

From a dimensional point of view, we classified the lacunas in the ampulloma in gaps with diameters between 1–3, 3–5, and over 5 cm.

It is proven that this neoplastic entity is in the form of a small space replacement process, below 3 cm in a percentage of 70%, the remaining 30% being tumors with dimensions between 3 and 5 cm. You can also see the absence of space replacement processes with dimensions over 5 cm.

Semelka et al. [19], following a study carried out over a 2-year period, regarding the ampullary carcinoma, have concluded that the dimensions of this type of neoplasia do not exceed 5.5 cm.

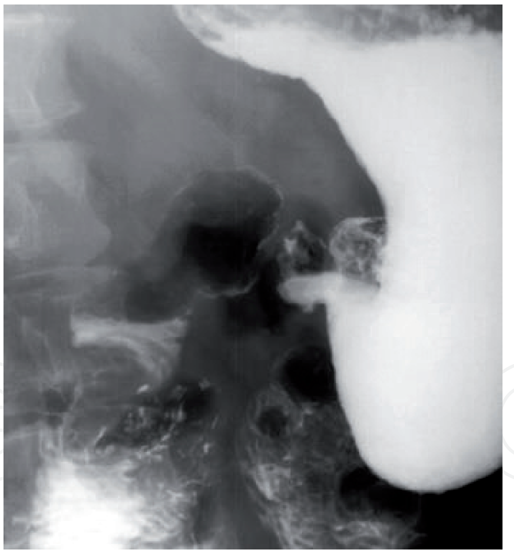

Figure 4.
The lacuna in a vaterian ampulloma.

These are arguments in favor of the authors' assertions that vaterian carcinoma is largely the result of malignant transformation of an adenoma.

Also, the reduced size and the histopathological nature of the ampullary adenocarcinoma lead to the conclusion that this **type** of neoplasm is one with reduced aggressiveness.

The conventional radiological examination is excellently complemented by the computed tomographic exploration or by magnetic resonance that can detect space replacement processes with dimensions up to 1 cm. These are seen as small occurrences in the duodenal lumen, which cannot be detected by the standard radiological examination.

The report of detection of space replacement processes by the two associated methods, the examination of the duodenum in double-contrast and computed tomography or MRI, actually highlights a double number of processes of space replacement at the level of the ampulla of Vater, regardless of its size. Comparison of these two exploration techniques with each other, but also with endoscopic exploration, reveals a greater specificity of magnetic resonance exploration than computed tomographic exploration.

Semelka et al. [19], in a study on the reliability of radiological and imaging scanning techniques versus ERCP, concluded on the superior specificity of magnetic resonance scanning compared to computed tomography. At the same time, considering the potential risks of retrograde endoscopic cholangiopancreatography, it recommends MRI as the diagnostic method with the highest degree of specificity.

In conclusion, we have considered all the radio-imagistic methods of detecting the process of space replacement in the case of the vaterian ampullomas, which we presented at the beginning of this subchapter.

3.3 The presence of the Frostberg sign

The Frostberg sign, also known as the inverted "3" sign (**Figure 5**), represents, from a radiological point of view, a semiological contour modification, which translates into an enlargement of the duodenal papilla, in the center of which the insertion of the biliary and pancreatic ducts remains fixed.

From the etiological point of view, this radiological modification is nonspecific; it can be present both in the malignant tumors of the ampulla of Vater and in any enlargement of the head of the pancreas, whatever the cause.

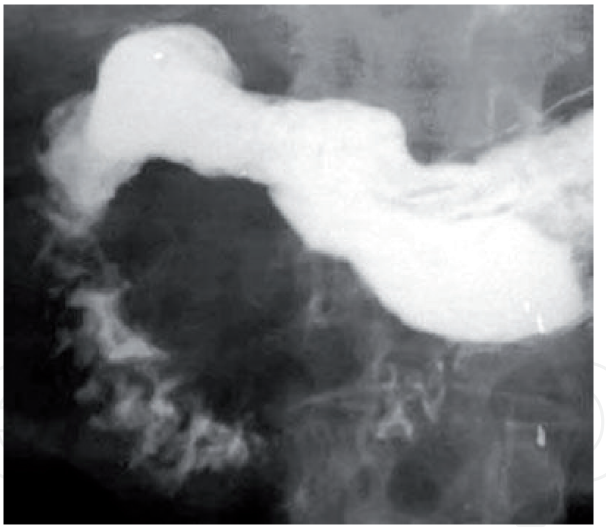

Figure 5.
Frostberg sign.

The existence of Frostberg's sign actually pleads for the secondary invasion of the ampullar "carrefour."

Radiologically the two convexities connected between them represent in fact the edges of the papilla, and the opacified spines between them correspond to filling the papillary orifice with contrast agent.

The existence of the Oddi sphincter, but at the same time the tumor infiltration, does not allow the reflux of the contrast agent neither in the duct of Wirsung nor in the main biliary duct.

The conventional treatises of conventional radiology place Frostberg's sign as the second in frequency in the radiological semiology of the vaterian ampulloma. At the same time, the specificity of this radiological manifestation is relatively small, recognizing that translating the enlargement of the papilla, in fact a papillary suffering, is incriminated, without being able to indicate its substrate.

Ferruci [20] considers the Frostberg sign to be a relatively rare sign, which has specificity with regard to the damage of the duodenal papilla, without being able to define the cause of this change.

The presence of the Frostberg sign in almost 60% of cases is detected in the vaterian ampullomas.

Although not pathognomonic, it is also found in pancreatic disorders; the Frostberg sign is frequently detected in ampullary carcinomas. With it we can differentiate, using the conventional radiological exploration only as a method of investigation, the vaterian ampulloma from the primitive duodenal malignancies. This assertion is based on the fact that any primitive malignant tumor, in which the developing area also includes the papilla, infiltrates the ampullae by erasing its outlines and damaging the specific architecture of the papillary folds.

Being a radiological contour modification, in the case of the double-contrast duodenum examinations, an exploration that achieves the maximum luminal distension is much better highlighted and thus reveals the finest modification of the duodenal contour.

3.4 Rigidity

In the case of ampullary adenocarcinomas, the segmental rigidity, from the level of the internal contour of the descending duodenum, above and/or underlying the tumor lesion, translates the neoplastic invasion by contiguity of the duodenal wall itself.

It is considered that the presence of rigidity on the internal contour of the descending duodenum is a radiological sign, which, associated with the lacuna, gives the radiological image a certain specificity regarding the vaterian ampulloma.

Taking into account the pathophysiological substrate of rigidity and considering that the vaterian ampullomas are neoplasms with reduced aggression, a small percentage of only 20% is explained, so the duodenal invasion is present in less than a quarter of cases [1].

The presence of rigidity is considered important because it is one of the first signs that can be highlighted by the standard radiological examination, especially by the double-contrast probe duodenography, the method that achieves the most reliable distension of the duodenal lumen. Highlighting a segment that presents rigidity, including the duodenal papilla, may be useful in associating the Frostberg sign. In this case, a radiological differential diagnosis can be made between the vaterian ampulloma and papillary disorders of other etiologies. The presence of rigidity in the absence of the Frostberg sign reduces the probability of the existence of a vaterian ampulloma, but it cannot completely exclude this diagnostic possibility. At the opposite pole is the hypotonic duodenography, which, due to the lack of duodenal functional information, highlights the rigidity with more difficulty.

From a dimensional point of view, the rigidity in the case it exists within the vaterian ampulloma has dimensions between 3 and 5 cm.

3.5 The imprint

Ferruci [20] considers the imprint an important sign of conventional radiological exploration in detecting a space replacement process located in the vicinity of the duodenum, without necessarily having the meaning of a neoplasm.

Although it is an intrinsic neoplastic process, the vaterian ampulloma may induce imprinting due to the accompanying pancreatic reaction or, another explanation would be that the vaterian ampulloma invaded the pancreas. Regardless of the nature of the cause in the situation of the vaterian adenocarcinoma, the impression is the result of the dimensional increase at the level of the head of the pancreas.

In the case of the vaterian ampullomas, the imprint is found in up to 20% of cases.

The vaterian neoplasm is not a type of malignancy of the duodenum, but is localized within the duodenum, the vaterian ampulla being not a neighboring organ.

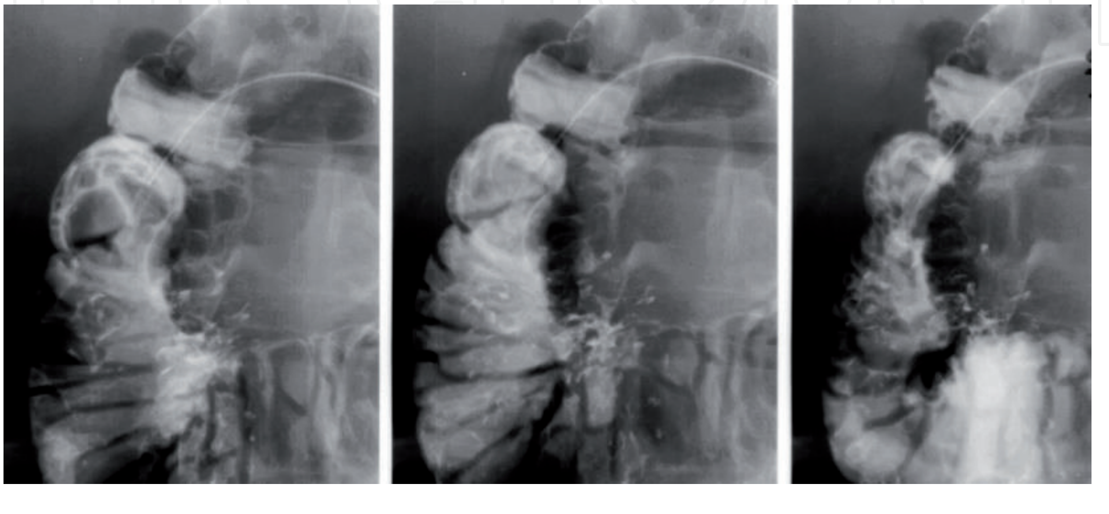

Figure 6.
Vaterian ampulloma: Imprint.

The imprint may occur due to the segmental enlargement of the head of the pancreas, due to the perilesional edema.

In any case, the imprint due to vaterian ampulloma is less spread on the contour of the descending duodenum than in the case of pancreatic cephalic malignancies. In the case of neoplasms with localization in the head of the pancreas, the association of changes in the extremity of the mucosal folds in the vicinity of the neoplasm is mentioned almost constantly, by the appearance of what bears the name of "T fold." Vaterian ampullomas never associate this change in orientation of the mucosal folds (**Figure 6**).

The presence of the imprint could possibly be a radiological sign of differentiation between the duodenal malignancies and the vaterian ampullomas but with a higher specificity between the duodenal tumors and any other tumor spread to the level of the descending duodenum.

3.6 Changes of mucosal folds

Although the tumor process originates from the epithelium of the structures of the ampulla of Vater, its location makes the effect on the duodenal mucosal folds important.

In 70% of vaterian ampullomas, modifications of the mucosal folds are described, and unlike the primitive duodenal malignancies, there are also 30% of cases in which there is no evidence of duodenal mucosal damage.

Alignment of the extremities of the folds on the internal contour of the descending duodenum may indicate a neoplastic process, either ampullary or neighboring—head of the pancreas–but may also be encountered in the case of pancreatitis or perivisceritis, being a nonspecific sign. In the case of the vaterian ampullomas, the alignment of the folds takes place above the papilla (**Figure 7**).

The presence of disorganized folds, although reduced in number, is important from a diagnostic point of view [1], being considered the disorganized folds in the descending duodenum as a sign of damage to the duodenal papilla. It can be concluded that this type of radiological modification cannot differentiate between ampullary malignancies and invasion of the ampulla of Vater by pancreatic cephalic neoplasms.

A more important extension at the level of the duodenal mucosa determines the presence of folds interrupted at the level of the second topographic segment of the duodenum.

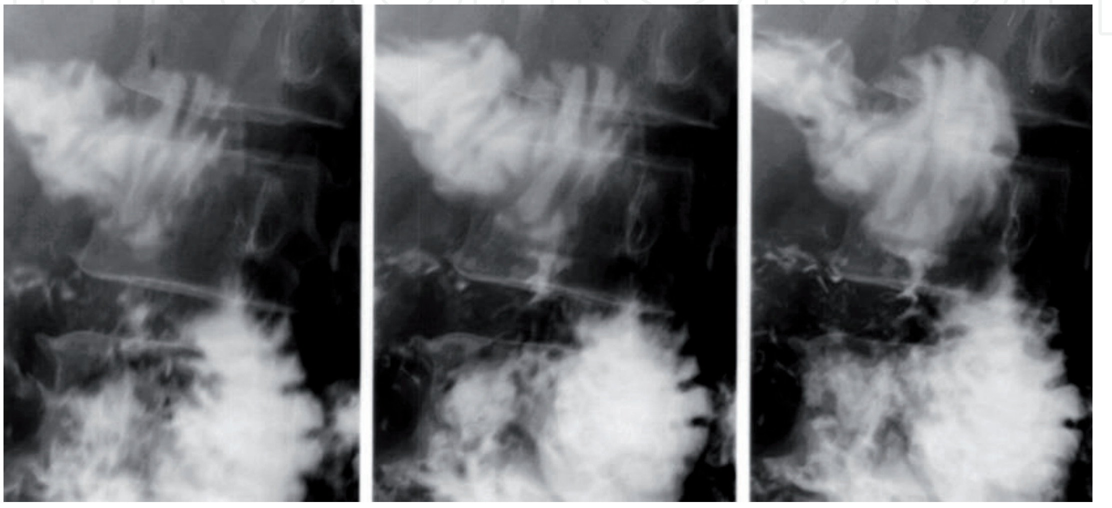

Figure 7.
Folds aligned above the lesion.

The existence of ampulla of Vater adenocarcinoma does not, however, require the disappearance of all mucosal folds at the papilla level. A neoplastic infiltration of the papilla can lead to the deletion of the longitudinal fold and at the same time to a thickening of the superior fold, in which the diagnosis can only be made endoscopically, possibly with the association of multiple biopsies.

It should be noted that the dual contrast method of duodenography allows for a much more reliable study of mucosal folds, especially those at the duodenal papilla level, which requires maximum distension of the duodenal lumen, as well as double-contrast air-barium exploration.

3.7 Thickness of the duodenal wall

Direct measurement of the thickness of the duodenal wall, either by computed tomography or magnetic resonance examination, is one of the most reliable indicators that show the damage of the duodenal wall, regardless of whether it is a neoplastic invasion or an inflammatory reaction (**Figure 8**).

If one compares the changes in the thickness of the duodenal wall from the duodenal tumors and the vaterian ampullomas, it is concluded that the ratio is exactly reversed, that is, in the case of the ampullomas, the probability that the duodenal wall has a normal thickness is 80%. Thus, the thickened wall raises the assumption of a primitive duodenal neoplasm more quickly than of a vaterian ampulloma but does not exclude it.

At the same time, the analysis of the dimensions of the parietal thickening according to the classification in the three subgroups, namely, the wall thickness with values between 4–6, 6–8, and over 8 mm, will show that in the case of the vaterian ampullomas, the wall can be thickened only up to 6 mm.

In conclusion, in the case of an ampullary neoplasia besides the fact that the probability of the presence of a thick duodenal wall is relatively small, in less than one fifth of cases, this thickening is minimal, the duodenal wall not exceeding 6 mm, as opposed to the duodenal malignancies in which at least in two-thirds of the cases we encountered a parietal thickening of more than 6 mm.

Also, the parietal thickening, in the case of neoplasms of the ampulla of Vater, has been shown to be unilateral, so it is an impairment of the duodenal wall through contiguity and at the same time limited.

The measurement of the parietal thickness is done either within the CT scan or by magnetic resonance scan, the results being identical [1, 21, 22].

3.8 Tumor extension

As with parietal thickening, the study of tumoral extension, either by contiguity, or by lymphatic or blood route, of the vaterian ampullomas is carried out by the

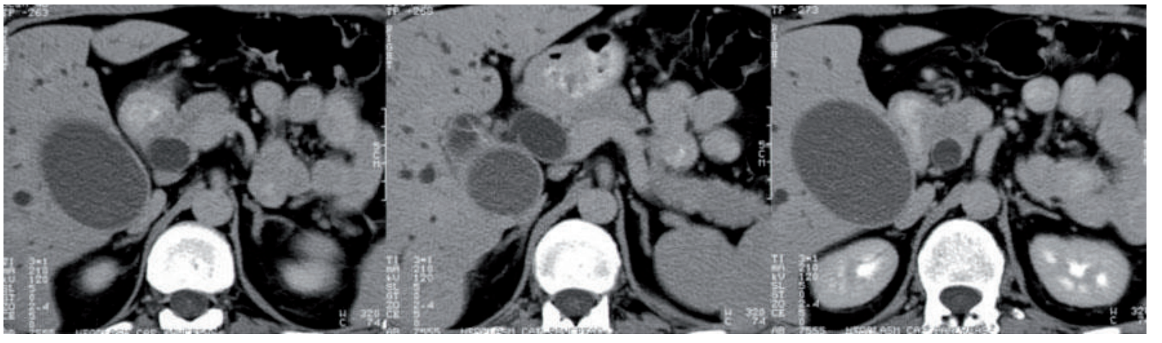

Figure 8.
Duodenal parietal change in the papilla.

two radioimaging methods, namely, computed tomography and magnetic resonance imaging. The comparative results of the two methods proved to be identical.

The extension by contiguity, in the case of the ampullary neoplasms, consisted in reality only in the invasion of the pancreatic cephalic portion, the periduodenal space, as we described in the previous subchapters being normal.

Invasion of the head of the pancreas can be detected only in up to 20% of patients with vaterian ampulloma.

If we compare the existing data with those described in the case of the primitive duodenal malignancies, it can be observed that the numbers and the percentages of pancreatic invasions in the case of duodenal neoplasms are higher than the results in the case of the vaterian ampulloma. Thus, duodenal malignancies invade the pancreas in about 30% of cases, while in the case of ampullar carcinoma, this percentage is only 20%. This is an additional argument to support the idea that the vaterian ampulloma is a less aggressive form of neoplasm, even more "benign" than primitive duodenal malignancies.

The lymphatic extension results in radio-imagistic findings of adenopathy. In specialized literature, they are described as being possibly present in the case of vaterian ampullomas, as claimed by Semelka et al. [19], but they are extremely rare.

Extension through the bloodstream is evidenced by the presence of organ metastases, respectively located in the liver. Semelka et al. [19] describes the possibility of the existence of liver metastases in the case of the vaterian ampulloma.

The frequency of metastasis in ampullary neoplasms has been shown to be lower than in the case of primitive duodenal malignancies.

In conclusion, the vaterian ampullomas are neoplasms with reduced aggression, which is why Talamini et al. [2] state that compared to pancreatic carcinomas, ampullary carcinomas have a significantly higher resectability rate and a much better prognosis.

3.9 Modifications of the biliary and pancreatic ducts

If, in the case of the duodenal neoplasms, the impairment of the bile ducts was only limited to the increase of the choledoch caliber in a few cases, the dilation in these cases was moderate, that is, it did not exceed 1.5 cm; in the situation of the vaterian ampullae, an enlargement of the bile duct tree size is detected in all cases.

In order to be able to classify the caliber changes of the biliary ducts, we divided the cases into three groups, namely, those with a diameter of less than 1.5 cm, but over 0.9 cm, those with diameters between 1.5 and 2 cm, and those with a caliber of over 2 cm.

The value of 0.9 cm is considered by all authors to be the maximum value of the choledoch duct that can be considered normal.

It can be seen that most of the vaterian ampullomas, that is to say, 70% have a choledoch with a size between 1.5 and 2 cm and over 20% with a size of over 2 cm. A percentage of less than 10% shows a moderate increase in the size of the choledoch duct, i.e., up to 1.5 cm [1] (**Figure 9a, b**).

Semelka et al. [19] concluded that most of the neoplasms of the ampulla of Vater are defined by a significant increase in the size of the choledoch duct, considered by him to be over 1.5 cm, and that only in a limited number of cases does the choledochal dilation not exceed 1.5 cm.

Regarding the radioimaging method for determining the dimensions of the choledoch duct, the same author, in a comparative study, concludes that the magnetic resonance scan, which also includes cholangio-MRI, is superior to the computed tomography, especially due to its ability to detect once again very small processes of

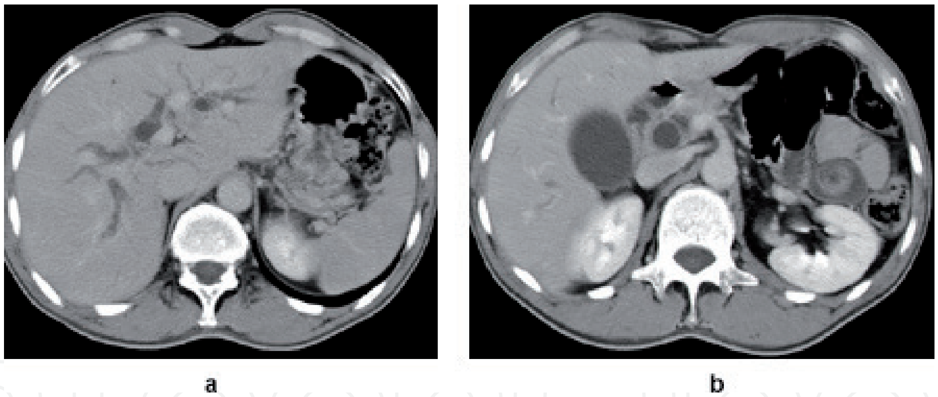

Figure 9.
(a, b) Changes of bile ducts in the vaterian ampulloma.

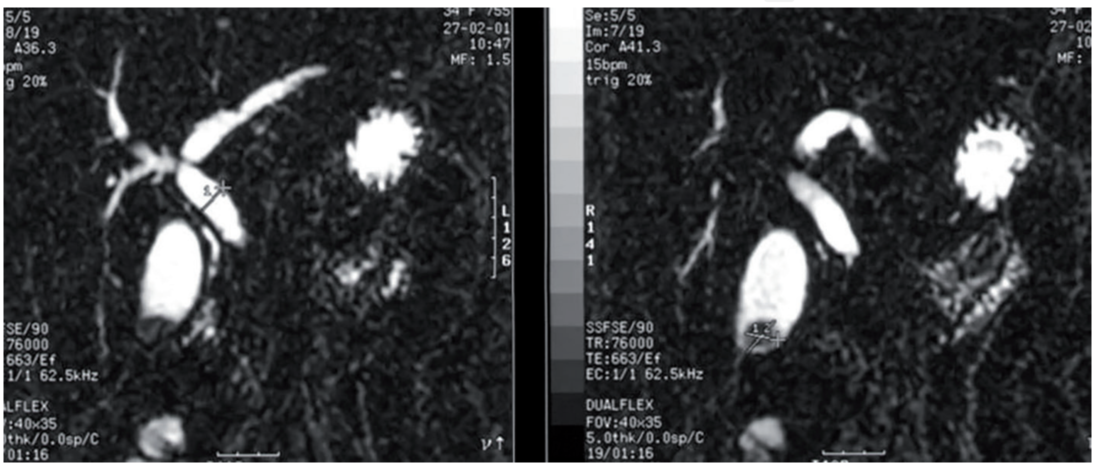

Figure 10.
Changes in the bile duct in the ampulloma: Cholangio-MRI.

space replacement at the level of the ampulla of Vater, which are not evidenced by the computed tomographic examination. He also argues that the magnetic resonance method is similar to ERCP from these points of view, but unlike the latter it is a noninvasive method.

If we compare it with the neoplasms of the head of the pancreas, we will notice that the dilation of the choledoch duct is reduced in terms of caliber, that is, in the case of pancreatic cephalic malignancies, the frequency of the presence of the choledoch dilation is much lower, of only about 30%, and dimensionally the choledoch rarely exceeds 1.5 cm.

Magnetic resonance exploration at the same time allows the study of the contours of the terminal part of the choledoch (**Figure 10**).

The existence of an irregular contour, particular to a neoplastic infiltration, cannot be discussed, considering that the Oddi sphincter usually represents an anatomical barrier in the superior extension of the tumor. The association of the terminal part of the choledoch narrowing with its irregular contours guides the diagnosis either toward a distal cholangiocarcinoma or in the case of a choledochal invasion by a pancreatic neoplasm.

This is the reason why the analysis of changes in the biliary duct was limited to dimensional evaluation.

Due to the anatomical position, the ampullar neoplasm also determines the dilation of the duct of Wirsung but only in a third of the cases. Semelka et al. [19] considers the presence of a high-caliber Wirsung as a nonspecific sign, accompanying the choledochal dilation, in a ratio similar to that found in our study.

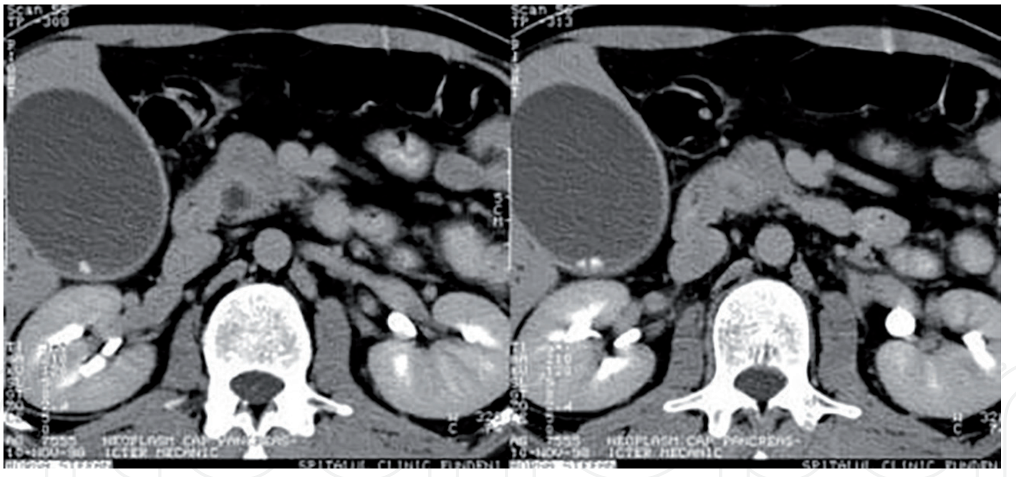

Figure 11.
Lithiasis and bladder distension associated with a vaterian ampulloma.

3.10 Changes in the gallbladder

In the case of the vaterian ampullomas, changes of the gallbladder can also occur, namely, in volume, wall, as well as the presence of calcifications inside (**Figure 11**).

The changes of the gallbladder are detected by computed tomography or magnetic resonance in 33% of occurrences in the case of the vaterian ampullomas, but without being able to distinguish if they were preexisting or caused by neoplasia [1].

Comparing to primitive duodenal neoplasms, there are no changes to the cholecyst.

It is considered that over 60% of the changes of the gallbladder in the tumor pathology of the duodenopancreatic region are detected in the cases of neoplasms of the ampulla of Vater. This leads to the conclusion that the presence of a gap in the periampullary region associated with changes in the choledochal caliber and with changes in the cholecyst leads the diagnosis to a vaterian ampulloma.

It is considered that there are no intracholecystic tumor masses and that the presence of vesicular lithiasis predominated in the case of the vaterian ampullomas.

In the case of ampullary carcinomas, there is no analysis of the changes of the vessels, due to their nonexistence, taking into account the anatomical reports of the ampulla of Vater.

4. Differential diagnosis

The vaterian ampulloma is a neoplastic entity with precise diagnostic elements, which reduces the list of possible differential diagnoses.

By anatomical topography, the only possible differential diagnoses are pancreatic neoplasm and duodenal malignancy.

For both diagnoses the role of CT and MRI is defined.

Pancreatic head neoplasm:

With the help of CT, but especially MRI, it is established from the beginning the location of the tumor mass, the size, the changes in structure, and the contrast of the pancreatic cephalic tumor mass. MRCP contributes to the analysis of changes in the biliary tree and duct of Wirsung, specific to pancreatic cephalic neoplasm.

Diagnostic elements from conventional radiological examination are not practically discussed.

Malignant duodenal tumors:

Historically, there were conventional radiological signs, most of them indirect, to suspect a malignant duodenal tumor.

Basically, the real differential diagnosis is made using CT/MRI examination.

Duodenal parietal changes, luminal stenosis, localization, structural analysis, and contrast enhancement are defining elements in establishing the diagnosis of duodenal malignancy.

Abbreviations

CT	computed tomography
MRCP	magnetic resonance cholangiopancreatography
MRI	magnetic resonance imaging
IV	intravenous
ERCP	endoscopic retrograde cholangiopancreatography
D2	descending duodenum

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